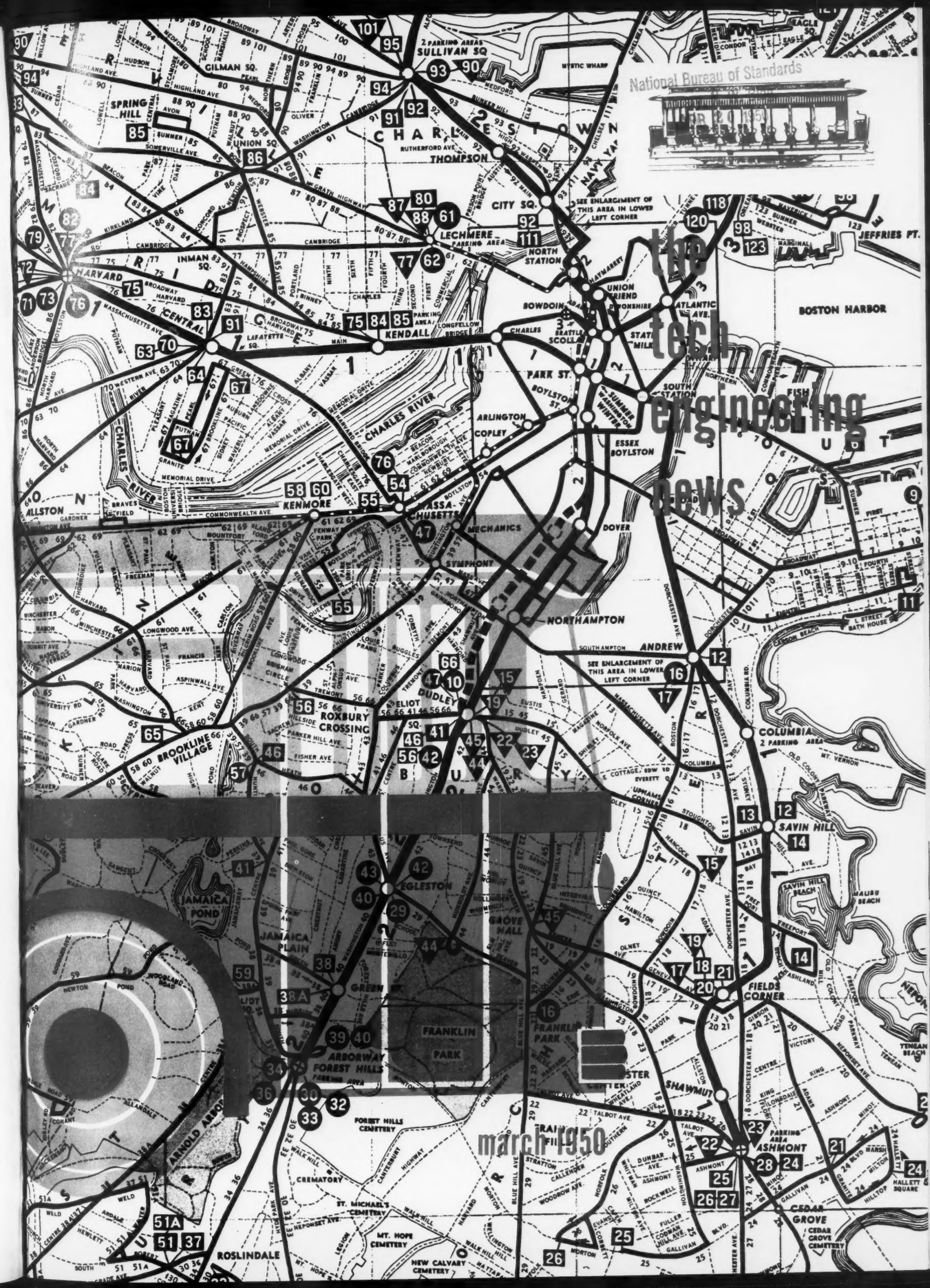
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the tech engineering news
march 1950

How to make 31,000 people happy

ONE of the biggest single housing developments ever undertaken has taken its place in the panorama of New York City's lower East Side. It is the result of cooperation between private enterprise, the State, and the City.

The rise of Peter Cooper Village and adjacent Stuyvesant Town has changed the face of this 80-acre section of Manhattan . . . has transformed a slum area of tenements and factories into modern, roomy living quarters for 31,000 people.

Many similar projects . . . some perhaps not so large, some even larger . . . must take form before America licks its housing problem. And they'll all require vast quantities of steel, for steel is the backbone of modern construction.

Today the steel industry is looking ahead toward tomorrow's big projects. At United States Steel, a vast training program is going forward continually, preparing men to handle the many highly-technical jobs that modern steelmaking involves. Many of these jobs are far removed physically from the roaring blast furnaces and glowing open hearths —at the same time, they are absolutely essential to today's precision steelmaking.

Through its training program, United States Steel is laying the foundations for promising futures for young men who meet its qualifications.

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UNITED STATES STEEL

"Where opportunity knocks every day"

This huge new building pictured above is one of the world's most modern petroleum research laboratories—those of the Standard Oil Development Company at Linden, N. J. It is the research center where Esso Products are constantly developed and improved by engineers and technicians whose aim is better products for better living all over the world.

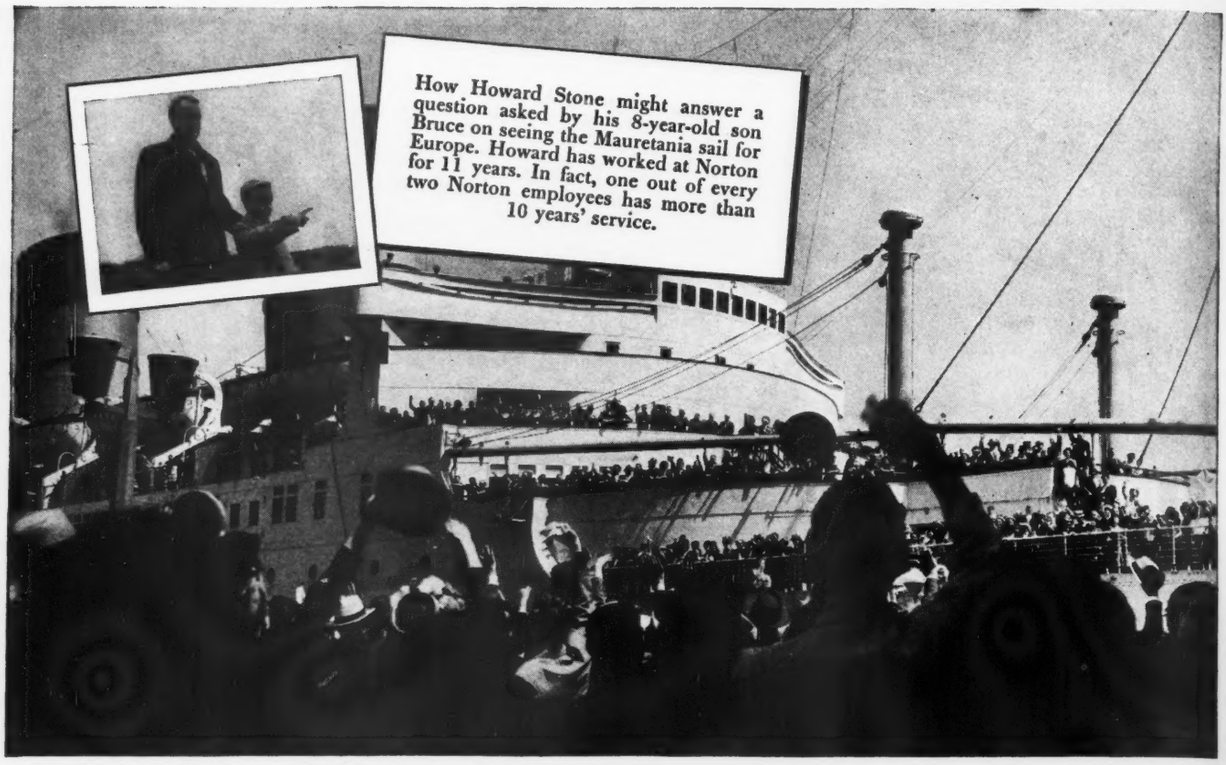
Here chemists and engineers find limitless opportunities for the scientific advancement of petroleum research. Scientific exploration in all the phases of oil production is constantly encouraged at Esso.

The 28,000 workers at Esso have been with the company an average of 13 years... 8,700 of them for 20 years or more. Esso is proud to have this large number of "career employees," enjoying fair pay, good working conditions, and a chance to learn more about the oil business and to advance in the company.

It has been an Esso Management policy for more than 30 years to keep *good people* happy at *good jobs*... and turn out consistently *good products* that carry the Esso trademark.

Esso

ESSO STANDARD OIL COMPANY



How Howard Stone might answer a question asked by his 8-year-old son Bruce on seeing the Mauretania sail for Europe. Howard has worked at Norton for 11 years. In fact, one out of every two Norton employees has more than 10 years' service.

"HOW BIG DO THEY MAKE SHIPS, DAD?"

"Almost no limit, son, as long as the men who design and build them continue to take advantage of scientific progress in all the things that make ships strong, fast and safe.

"Things like the ship's steel plates. They must be just right. That's why the powerful rolls that form them in steel mills are kept smooth and true with big Norton roll grinders and fast-cutting Norton grinding wheels.

"To give today's floating cities extra speed and smoother sailing, propellers must have perfect surfaces... the kind that come from rough-grinding with Norton cup-shaped wheels and finishing with Behr-Manning abrasive discs.

"Yes, and attention to fine details is the sign of the wise ship designer. That's why the terrazzo floors in galleys of ships like the 'Queen Mary' get lasting, non-slip safety from a Norton product called Alundum aggregate."

"So, you see, Bruce, in these ways and many more Norton has a hand in making modern ships bigger and better... another proof that I'm not boasting when I say 'Norton makes better products to make other products better'."

NORTON

TRADE MARK REG. U. S. PAT. OFF.

Making better products to make other products better

ABRASIVES · GRINDING WHEELS · OILSTONES · ABRASIVE PAPER & CLOTH

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THE DU PONT DIGEST

Science Makes a Better Mop

Cleaning tasks lightened by new Du Pont cellulose sponge yarn

An ordinary mop has a bad habit of unraveling. It often leaves a trail of lint. And it wears out fast. A man who sold yarn to mop manufacturers decided to do something about these nuisances. Perhaps some reinforcing material might be combined with the yarn. He did some experimental work of his own but more and more he wondered if it might be possible to use a cellulose sponge coating.

THREE YEARS OF RESEARCH

So the man called on Du Pont, the company that had introduced the cellulose sponge to America in 1936. The suggestion of a sponge yarn presented a challenging problem.

Some way would have to be found to extrude a tightly fitting cellulose sponge jacket around each strand of the yarn. The whole sponge process would have to be adjusted for use in an especially designed machine. Du Pont chemists and engineers tackled these problems.

Even the very first cellulose sponge yarn produced experimentally made mops that were strong, absorbent and durable. But the process had to be changed and improved time and time again. Then the mops were tested in places where they would get the hardest usage—railroad stations, for example.

The mops performed so well that Du Pont built a pilot plant near Buffalo and, under a license from the man who had the original idea, manufactured the yarn on a small scale. Only after three years of study and testing was Du Pont able to offer mop manufacturers the yarn in commercial quantities.

CROSS-SECTION *of the new mop yarn. Each cotton fiber strand is jacketed with cellulose sponge material.*

FASTER AND CLEANER

Mops made with cellulose sponge yarn pick up and retain so much water they need wringing less often. You can mop a floor with them in far less time than it formerly took. They dry quickly, leave no lint. They outwear other mops three to five times. Best of all, perhaps, they stay dirt-free longer than ordinary mops. Here is something women will appreciate—a *clean* mop!

The introduction of these new cleaning tools is another example of how business firms of all sizes depend on each other. The Du Pont Company had facilities for specialized research on cellulose sponge. Because Du Pont could supply sponge yarn economically, some twenty mop manufacturers today have a better product that saves maintenance people and the American housewife time, labor and money.

★ ★ ★

SEND FOR "The Story of Cellulose," a 43-page booklet that tells how wood and cotton are transformed into sponges, textile fibers, lacquers, plastics, coated fabrics, Cellophane and many other useful products. Illustrated with photographs, charts and chemical equations. For free copy, write to the Du Pont Company, 2503 Nemours Bldg., Wilmington 98, Delaware.

DU PONT
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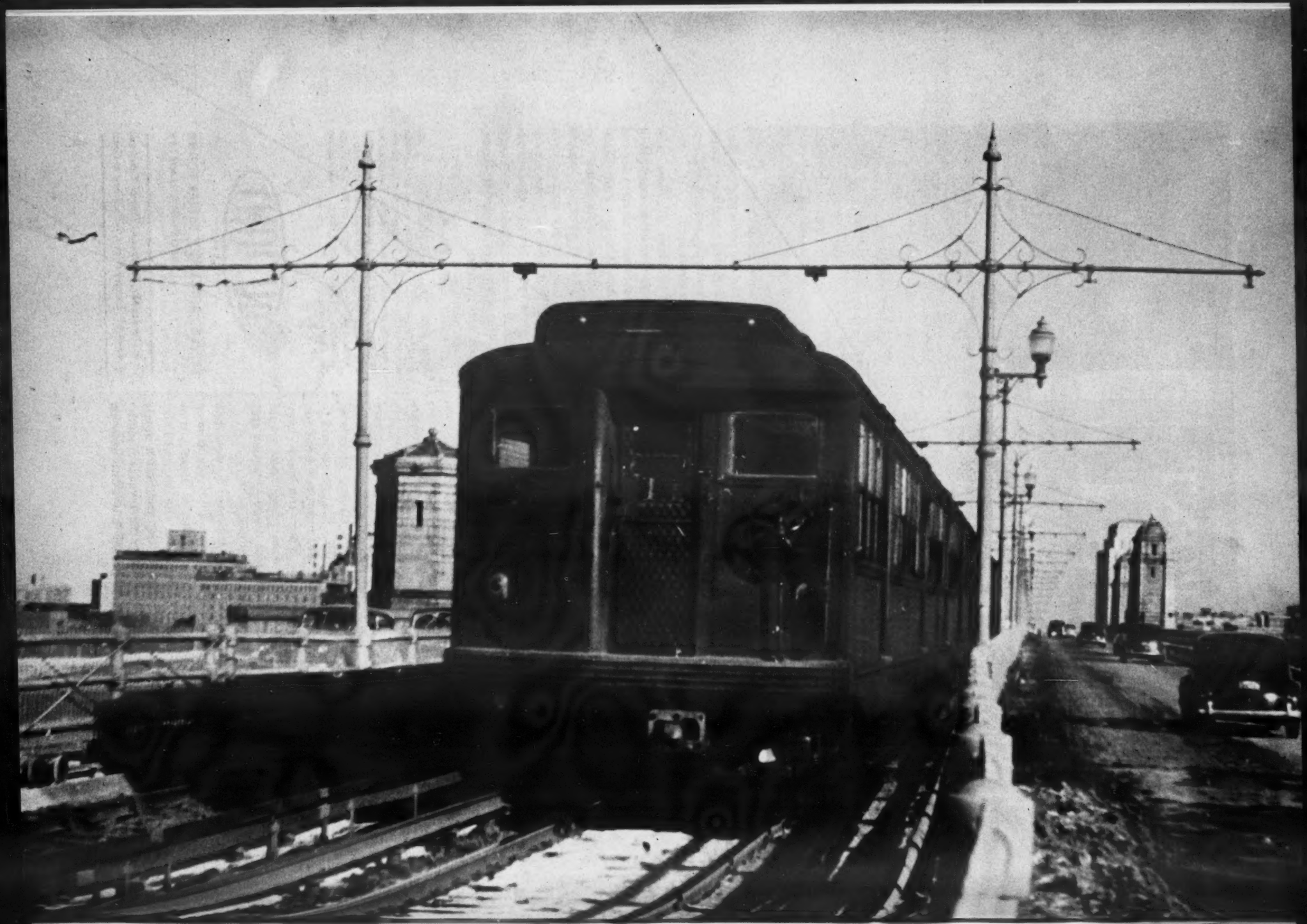
...THROUGH CHEMISTRY

Great Dramatic Entertainment—Tune in "Cavalcade of America" Tuesday Nights, NBC Coast to Coast



tech engineering news

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nine minutes to park street

The Development of Boston's Subway System

By Dave Klepper, '52

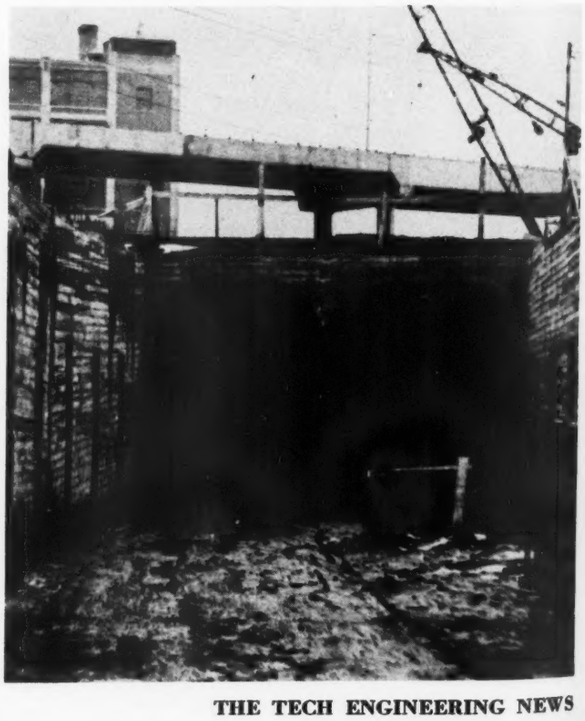
Urban transportation in the Boston area began in the era after the War of 1812, when horses first began plodding Boston's streets, drawing small omnibuses. These public omnibus lines flourished and grew until, on March 26, 1895, the first street railway was opened from Harvard Square to the Toll House near the Charles River in Boston. The Cambridge Railroad Company was engaged in a race with a rival line for the honor of being the first street railway to operate in Boston. It won the race, for while its rival was waiting for horsecars from the car builders, the Cambridge line bought cars second hand from New York. During its first two months of operation the line carried its patrons free and, consequently, was extremely popular. A wave of resentment swept through Boston Town when its fare was set at ten cents. Numerous other horsecar companies came into being and spread a web of iron throughout the area, but as weaker companies were absorbed by the stronger only a few separate companies remained. These were consolidated by Mr. H. M. Whitney into the West End Railroad Company in 1887.

After visits to several electrified railways, Mr. Whitney decided that electric power should be tried on his West End Railroad. The first line electrified ran from Park Square to Brighton with a branch to the Chestnut Hill Reservoir. Because the city fathers had an objection to overhead wire being used in the downtown area, a conduit, underground current collection, system was installed from Park Square to Charlesgate. The success of the overhead system, a demonstration of which was conducted for the city fathers by Mr. Frank J. Sprague, together with the panic created by a spread of epidemic among street railway horses, allowed the West End Railroad to abandon the expensive conduit system and replace it with overhead wire.

Streetcar traffic increased steadily until traffic congestion on Tremont and Washington Streets was acute; the Boston Rapid Transit Commission was formed to deal with this problem. It recommended that the city construct a subway under Tremont Street to serve as the downtown terminal for the streetcar lines and that a private company construct elevated rapid transit lines. The Boston Elevated Railway was incorporated by the Massachusetts Legislature and given the power to construct elevated lines in 1894. Believing that rapid transit could only exist as part of a unified transport system, the Elevated leased the West End Railroad in 1897 and has owned it outright since 1911.

The Tremont Street Subway was opened by the Commission for West End Railroad surface cars which entered the Subway from Boylston Street at the Public Garden Incline. It then extended only to Park Street Station. New inclines at Pleasant Street, now Broadway, were opened a year later, in September 1898, and the Subway was extended north of Park Street to inclines at Causeway Street, near North Station. Cars from South Boston, Roxbury, East Cambridge, and Charlestown could then enter the Subway, so all streetcar tracks were removed from Tremont and Washington Streets. The Tremont Street Subway was four tracked from Boylston Street to Park Street and north of Scollay Square. Loops for turning cars were located at Adams Station, Scollay Square Station (Brattle Street Loop) and north of Park Street Station. Two mistakes were incorporated into the Subway by the early commissioners. One, limiting the size of the Park Street Station for fear of undermining a line of old elms which later were found to be rotten and were cut down, was corrected later; the original platforms were enlarged twice; and, in 1936, a completely new platform, east of the northbound track, was constructed. The other mistake, the construction of but two tracks between Park Street Station and Scollay Square, is still to be corrected.

In 1914 the Boylston Street Subway was opened from an incline east of Kenmore Square to a connection with the Tremont Street Subway at the site of the former connection for the Public Garden Incline. This incline was replaced by one in the roadway of Boylston Street. A new station was constructed at Kenmore Square in 1932, and new inclines were constructed replacing the old one and permitting the trolleys to emerge directly on their center reservations on Beacon Street and Commonwealth Avenue, thus avoiding all traffic at Kenmore Square. In 1912 an elevated for trolleys was opened from North Station via the East Cambridge Viaduct on the north side of the Charles River Dam to



An extension of the East Boston Tunnel from Maverick to Orient Heights is under construction. Here, near Logan Airport, the trains will emerge from the Tunnel and change from third rail to overhead wire power collection.

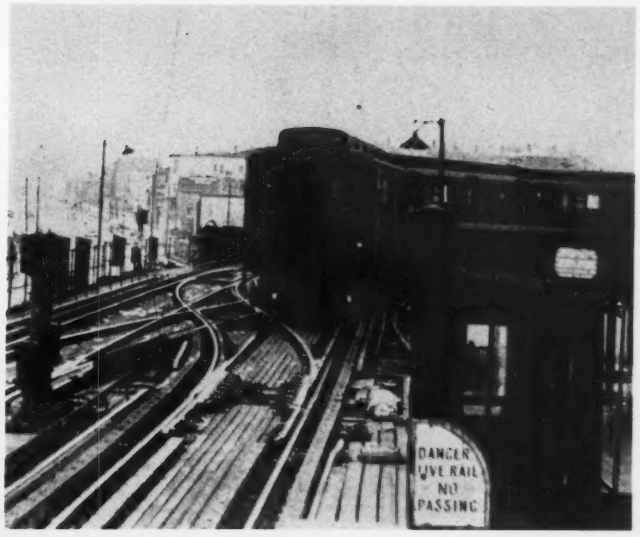
A Washington Street Tunnel train from Everett rounds the loop at Sullivan Square. Track to the left leads to the yards.

A center entrance train bound for Braves Field emerges from the Boylston Street Subway at Commonwealth Avenue.

Lechmere Station in East Cambridge. The incline in the roadway of Boylston was removed when the Huntington Avenue Subway was opened in 1941. The opening of this line, from Copley Station on the Boylston Street Subway to an incline at the Opera House, completed all underground lines presently used by trolley cars.

Soon after the Tremont Street Subway was opened, the Boston Elevated Railway started construction of its elevated. Originally it was planned to build an elevated structure of the unique Meigs type, which would have provided for car axles at forty-five degrees from horizontal to provide stability; but this proved too costly, so a more conventional type was used. The original line ran from Sullivan Square, Charlestown, over a drawbridge spanning the Charles River, to a connection with the outer, through, tracks of the Tremont Street Subway. At Pleasant Street a new incline to the elevated replaced the older surface car inclines; here an elevated station was built. South of here the elevated curved to Washington Street upon which it ran to Dudley Street. At both Sullivan Square and Dudley, elaborate stations were constructed permitting surface cars of feeder lines to enter the elevated stations. Both of these arrangements had to be altered lately to provide for the entrance of trolley buses. Another elevated route left the main line near Pleasant Street and ran via Atlantic Avenue and Commercial Street to North Station. This line, the Atlantic Avenue Loop, was abandoned in 1941.

Because the main line elevated trains used the Tremont Street Subway's outside tracks from the Pleasant Street Incline to North Station, the surface cars that had previously entered the Subway at Pleasant Street were looped under the new Pleasant Street Elevated Station; cars entering at the Public Garden used the inner tracks to Park Street where they looped; and all cars from the north had to loop either at Adams or Brattle Street. Aside from the laying of third rail, extensive changes had to be made in the Subway itself: the tunnel had to be widened, and station platforms had to be raised. The entire elevated service was opened with rapid transit cars in 1901. Soon after, the construction of the Washington Street Tunnel commenced. Upon its opening, elevated trains were shifted from the



Tremont Street Subway, and surface cars could again have exclusive use of the Tremont Street Subway. The elevated was extended south to Forest Hills, where a neat concrete station was constructed, in 1916, and north to Everett in 1919.

The East Boston Tunnel was opened to streetcars from Jeffries Point, Orient Heights, and Chelsea in December 1904. The Tunnel ran from a surface incline at Maverick Square to a station at Court Street, near Scollay Square. An extension under Scollay Square Station to Bowdoin Station and an incline on Cambridge Street, which permitted cars to operate from the Tunnel over the Longfellow Bridge to Cambridge and Watertown, was opened in March 1916. A turn around loop was constructed at Bowdoin Station to permit most of the cars to turn back there. Traffic increased on this line until no more passengers could be handled by the streetcars using the Tunnel; consequently, the Boston Elevated Railway decided to replace these streetcars by rapid transit trains. A new station was constructed at Maverick, with a turn around loop, storage tracks, and a small shop; third rail was laid throughout the Tunnel, and station platforms were raised. The Tunnel was reopened for rapid transit trains on October 3, 1914, streetcars having been removed three days earlier.

The Cambridge Main Street Subway was built by the Boston Elevated from Harvard Square to the Longfellow Bridge. At Harvard Square the inbound and outbound tracks are on different levels; this is also true of the surface car tracks, including the trolley bus roadway, which enter the Tunnel for underground interchange with the rapid transit. At the end of the Harvard Shops away from Harvard Square, next to the Charles River, is located the Stadium Station, in use only before and after Harvard Stadium ball games. On the Boston side of the Charles, the Transit Commission built the Cambridge connection from the Longfellow Bridge to Park Street Under Station. Here were located scissors crossovers to permit rapid reversal of trains. The entire Cambridge Subway, from Harvard Square to Park Street Under, was opened in March 1919. It was extended, by the construction of the Dorchester Tunnel, to Washington Street Station, where passengers are exchanged with Washington Street tunnel trains, in April 1915. The Dorchester Tunnel reached South Station in December 1916, Broadway a year later, and, during the following year, Andrew. At Broadway Station there were underground platforms, tracks, and inclines for interchange with surface cars, but these have since been discontinued.

A few years ago trains of old center entrance cars were a frequent sight on the East Cambridge Viaduct. Now one rarely sees anything but modern P. C. C. cars.

A late model P. C. C. car emerges from Boston's oldest subway, the Tremont Street Subway, at Shawmut Avenue. Tracks to the left are used by Egleston streetcars.

Surface platforms for interchange with the Broadway-City Point car line, which runs from Tremont Street Subway, are still in use. At Andrew Station a building on the surface was constructed for passenger interchange with surface cars; today the Dudley-City Point cars use it as well as Franklin Park and Fields Corner trolley buses.

To extend the line further south, an abandoned New Haven Railroad line was used. The Boston Elevated Railway equipped the line and rebuilt the stations, as well as erecting new ones, for rapid transit service. Service to Fields Corner began in 1927; the next year saw service extended to Ashmont Station. Both these stations are built for direct, across the platform, interchange between rapid transit trains and surface cars. Unfortunately, the buses and trolley buses which have largely replaced these surface trolleys do not have doors on their left sides. Thus, passengers wishing to board or alight from a bus at these stations must of necessity cross in front of the vehicle, creating a hazard.

South of Ashmont the population was not dense enough to support the extension of rapid transit; so the Elevated decided to rebuild the remainder of the railway line for high speed trolley operation. On December 21, 1929, trolleys began running via the High Speed Line from Ashmont to Mattapan, and buses took over the surface route between these points. At Mattapan a large trolley terminal and yard were constructed; here passengers are interchanged between the High Speed Line, two car lines operating on highways, two MTA bus lines, and private bus lines.

The equipment used on these rapid transit lines is as interesting a subject as the rapid transit lines themselves. The earliest cars, used in the Tremont Street Subway, were the same as any of the other surface cars operating in the Boston area. These were of two types. First, the open car, which had seats running crosswise from one side of the car to the other. The sides were open, and along the side ran one or two running boards which furnished entrance to the cars. They were very popular for summer travel but their limitations spelled an early doom. They were cold in the winter; the conductor, who had to walk along the running boards to collect fares, could not possibly reach all the passengers during rush hours, and the rush hour standee stood on the running board and therefore was in a dangerous position. Few of these cars were left by the time of the First World War. The other cars were side seater box cars, as they were known. These were completely enclosed cars, with doors at the four corners and longitudinal seats on each side of the car. All these cars were of wood construction. The first steel surface cars were built for the Elevated in the years between 1910 and 1912. These cars, known as type four cars, were very heavy and for many years pulled trailer cars through the subway. These trailer cars had center doors and side seats instead of the corner doors and reversible cross seats of the type four cars. Other cars, similar to the center door trailers but with cross seats, motors, and multiple unit control, were built especially for train service in the trolley subway. All these cars were built for two-man operation.

After 1918, when trustees took over operation in the name of the Commonwealth of Massachusetts, the

need for economy was felt. To this end eighty one-man small Birney Safety cars were bought. Although too small for Boston, these cars successfully demonstrated the practicality of one-man surface cars and, therefore, paved the way for an order of 275 larger lightweight one-man cars, known as type five cars, in the same year. Later orders brought the total number of these cars, whose interiors were similar to those of the type four cars, to 460, but they were used mostly on car lines that did not enter the subway. Later, the type four cars were converted to one-man operation.

Until 1937 Boston received no new trolley cars after the type fives. In that year, however, Boston's first P. C. C. car arrived. Because of its success more have been bought until today 271 are in service, of which 225 are operated in trains in service via the subway.

The first cars for the Elevated were, like the early trolleys, of mostly wooden construction. They had open platforms and wide center doors. Later, the platforms were enclosed, but the days of the wooden cars were numbered, for soon they were replaced by modern steel cars. The Cambridge-Dorchester Tunnel had steel rapid transit cars from the start. These cars were exceptionally long, 69 feet 2½ inches; this was permitted by the ample clearances and wide radius curves on the line.

In contrast to the Cambridge-Dorchester cars, the size of the East Boston Tunnel cars was severely limited by the size of the Tunnel; and in order to accommodate the passengers, seating was sacrificed for standing room. The new cars for this line, to be placed in service upon its extension to Orient Heights, will, nevertheless, embody all the advances made in rapid transit.

the lecture series committee

By Mel Siegel, '50

Shortly after World War II it became strikingly apparent that mere technical knowledge is inadequate for today's scientists and engineers, in view of the great social responsibilities which have been thrust upon them. Technology and the basic sciences would undoubtedly mold lives in an unprecedented manner and must be seen in context with social, political, and economic forces before active personalities can hope to understand the roles they play. At least such was the credo of Harold Salwen, '46, and Bob Davis, '47, when they organized a group of ten Tech students to do something about it back in the fall of 1946.

Their object was to present programs such as lectures and movies on non-technical subjects largely unknown to the average Institute graduate of former years. Congressmen, anthropologists, psychologists, artists, and various professors from liberal arts colleges were invited to speak at M. I. T., and at sporadic intervals Huntington Hall was filled with the strange sounds made by those who have little use for the oversize measuring devices at the front of the room. Meanwhile many faculty members, notably Professor Deutsch. Professor Keenan, Professor Coryell, and Dean Burchard, became convinced of the ability and willingness of the Committee to carry out such a program, whereupon they helped make possible, through their numerous and broad contacts, many of the events to be described.

In 1947 the Committee, which had been struggling along with small grants from various sources for publicity, received its first means by which it could request speakers whose travel expenses indicated that they had to come from somewhat more distant places than Lynn and West Newton. President Karl Compton made available a fund of $300 for speakers, and this amount permitted a level of activity which afforded recognition by the Institute Committee and a yearly grant as a student activity which has continued ever since.

The Lecture Series Committee now consists of twenty students headed by a chairman, vice-chairman, secretary-treasurer, and publicity manager. These offices are currently held by Mel Siegel, '50; Marv Baker, '51; Jerry Robinson, '51; Ted Lentz, '51; and George Pierce, '52. The principal work of Committee members is letter-writing, in addition to attempting to keep abreast of current affairs and sounding out fellow Techmen on the issues they would like to hear discussed. Roughly speaking, each of the members will write two dozen letters during a school year, receive one "bite," and follow it through. In the LSC office in Building 18 is a file of all past and pending correspondence. In addition, there is a cross-reference card catalogue of agencies, contacts and results, and persons who are referred to collectively on correspondence.

Nobel Prizewinner Harold Urey did not come to Tech under LSC auspices to talk science, but argued the case for a federal world government.

S. I. Hayakawa whose lecture on semantics last year drew one of the largest audiences for an LSC lecture.

Martha Graham's appearance last November involved LSC'S biggest project since its inception.

This arrangement should prove increasingly valuable in the years to come.

The correspondent is occasionally rewarded by comments such as this from a reply by author-editor E. B. White: "I got scared by a platform when I was a kid, and I have stayed away ever since." Or the following admission by Mrs. Edgar Snow: "I'm sorry to say that I do not make public talks at any time as I dislike it intensely and find it a traumatic experience that I can live without." One eager member volunteered to write dozens of letters each week, many of them to persons on the West Coast, who are especially reluctant to accept a lecture invitation. It turned out that this member was an autograph collector.

Yet the success of the Committee in presenting two or more programs per month may be attributed to something more than a statistical average percentage of acceptances amid much correspondence. Outstanding is the fact that most personages are flattered by a request to speak at M. I. T. and will come unpaid, whereas many other institutions or organizations would have to pay a fee. For this reason the Committee feels a sense of responsibility to the Technology community. Another advantage is the cooperative spirit encountered at almost every turn. The Humanities Division under Dean Burchard has been most helpful; in addition, much expense and effort have been saved through the cooperation of such organizations as the Cambridge Association of Scientists, the Cambridge League of Women Voters, the Harvard Law School Forum, and the Boston Society for General Semantics. At Tech. several student organizations, including TECH ENGINEERING NEWS, the Debating Society, and the Hillel Society, have aided in the planning and enacting of many programs.

The activities of the Committee have by no means been limited to sponsoring lecturers (of whom a few will be mentioned). A series of three films on the atomic bomb lured hundreds of Techmen out of their less sobering labs. A poll is generally conducted each year to determine in a more formal manner what students are interested in. The Committee has on numerous occasions aided the Administration in arranging and publicizing concerts and special events.

The largest single project recently undertaken by LSC was promoting and selling tickets for the Martha Graham dance program last November. While the Staff Players were preparing the stage of the Cambridge High and Latin School auditorium, Committee members were visiting local colleges to sell blocks of tickets. Nearly half the seats were sold at M. I. T., although saturation of this market seemed to occur quickly. With stories and advertisements in the Boston newspapers the house was eventually sold out to within a handful of four-dollar seats. This appears to be a stroke of plain pot luck, notwithstanding the fact that less modest members of the publicity staff attribute the result to a keen appraisal of the situation, depending upon frequent experience with publicity problems.

While taking up more square-foot-days of Institute bulletin board space than any other group at Tech, the Committee has learned a great deal about the pitfalls of selecting, requesting, and arranging for lecturers. Generally a member will greet an out-of-town speaker at the railroad or airline depot and escort him to his hotel or speaking or dinner engagement; upon several occasions the welcomer has looked in vain for a face in a photograph among a crowd at South Station and found the subject of his search only when the station was nearly cleared and the searcher was convinced that the photograph must be old and flattering!

Another difficulty with traveling lecturers was encountered when the Committee arranged a dinner at the Graduate House for Louis Mumford and several guests; Mr. Mumford's train arrived several hours late, and considerably after the assemblage's demands for food had been appeased! Tardiness among speakers is not uncommon, but complete disappointments without reasonable notice or adjustment are rare. (The expected Convocation address by President Truman was *not* arranged by LSC.) Señor Victor Raul Haya de la Torre, a Peruvian labor leader and head of the APRA party, was supposed to discuss "South America Tomorrow" a few seasons ago. Shortly after his name had been squeezed onto a set of posters he requested that "Tomorrow" be the following day; but tomorrow, or rather his speech, never came because he was detained in Washington. The subject was later covered by Tech's Professor de Santillana.

A polite refusal to speak constituted one of the last letters ever written by the late anthropologist Ruth Benedict. Her co-worker Margaret Mead introduced Techmen to the study last year in an afternoon lecture and evening seminar. Rockwell Kent had to cancel a promised date when he was stricken with appendicitis a few months ago. Rabbi Joshua Loth Liebman broke a tentative engagement when he was forced to go to

the hospital with a throat malady shortly before his untimely death.

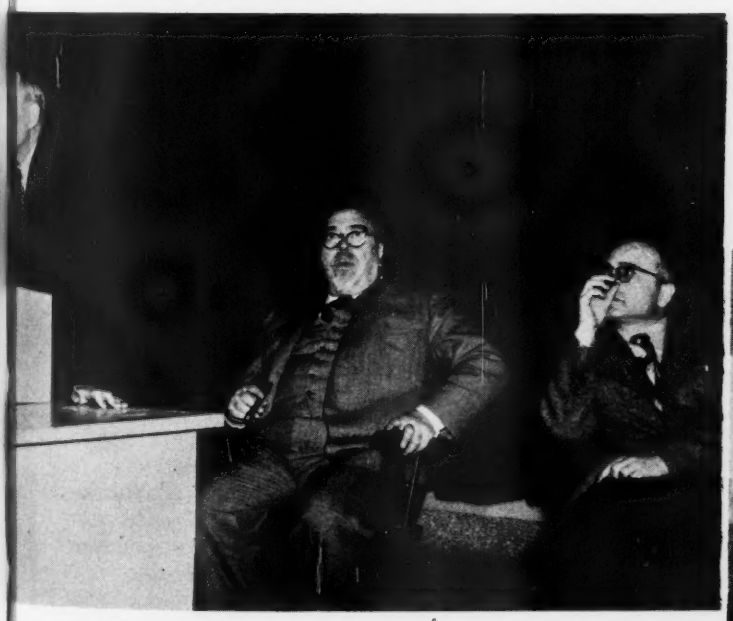
The Committee has received numerous requests for programs on religion. Here, as in the case of other topics, LSC attempts to present several points of view whenever possible. An early series of programs included talks by Rev. Gerald Walsh of the Society of Jesus, a Fundamentalist, and a "Liberal." Karl Compton discussed "Why Religion?" before a capacity audience in 10–250 recently. Mixed reactions greeted Woolsey Teller, Secretary-General of the American Association for the Advancement of Atheism (A. A. A. A.); Mr. Teller, incidentally, was disappointed at not being arrested for blasphemy, since he had obviously violated an old Massachusetts statute prohibiting the public denial of the existence of God. Such was not the case at a recent three-way forum on "Jesus — The Man and His Work," which featured a neo-Calvinist college professor, a Congregational minister, and a rabbi.

Two years ago Edward H. Carr, who was then editor of the London *Times*, gave us an early insight into Soviet sources of power; other aspects of this critical topic have been discussed by Professor Dirk Struik, General Frank Howley, and State Department Counselor George F. Kennan.

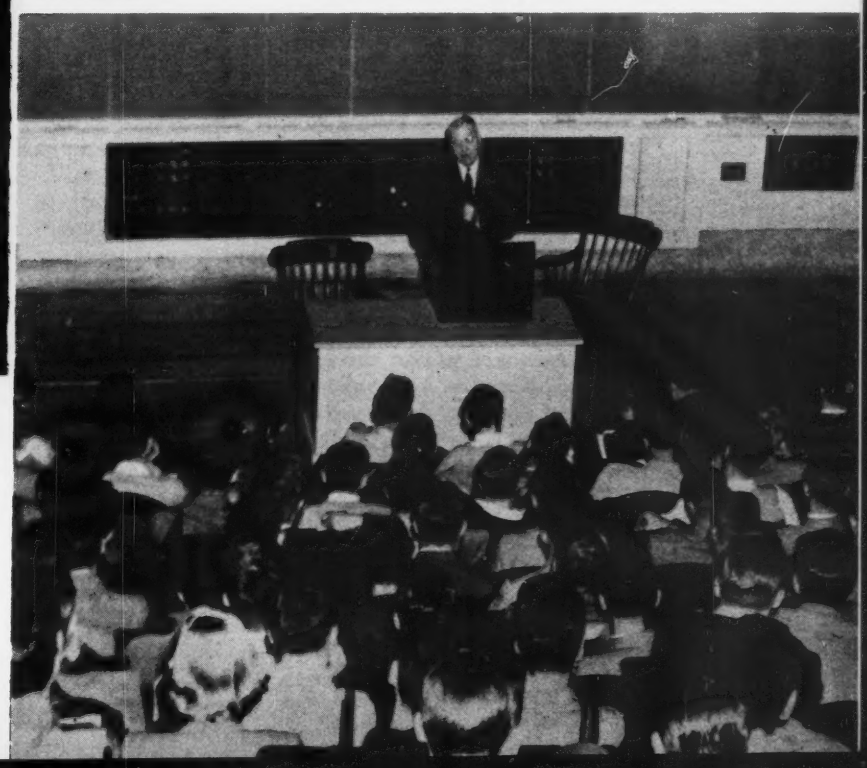
Besides Professor Magoun's marriage lectures (which were sponsored by the Technology Christian Association), many recent events have drawn capacity audiences or better at Huntington Hall. Names such as Robert Frost, Will Clayton, and Jan Masaryk were sure-fire. To the surprise of all, semanticist S. I. Hayakawa drew one of the largest audiences of last year. When the Committee discovered that the Tech Pharmacy sells more copies of *Astounding Science Fiction Magazine* than any other establishment (except a drugstore at atom-town Oak Ridge), editor John Campbell, Jr., an alumnus of M. I. T., was invited to tell an eager throng of Techmen about his favorite subject. Harlow Shapley, the eminent Harvard astronomer and world-traveler, has upon several occasions sent Institute audiences home with plenty to think about. The distinguished historian, Crane Brinton, was a rare treat, as was the noted Nobel-prize-winning chemist, Harold Urey, who pleaded for a federal world government. Parapsychologist J. B. Rhine captured the imaginations of another over-capacity audience when his apparently impeccable scientific description of the clairvoyance experiments at Duke University held the interest of several hundred students during a question period lasting more than two hours!

Professional lecturers are seldom seen at M. I. T. because LSC cannot pay normal lecturers' fees, which usually approximate the Committee's entire annual budget. This fact is always stated in the initial letter to a prospect, and it is sometimes difficult to decide whether a refusal is based upon a personage's policy of not speaking gratis, or whether the suggestion is considered presumptuous or highly inconvenient. Only rarely will someone be as candid as a famous poet who wrote, "I quite understand your financial difficulties, and I hope you will understand mine. . . ." Far more common is the sort of answer received a few weeks ago from Dwight D. Eisenhower, who stated, "As a matter of fact, between now and commencement in June, not half a dozen days remain free from major commitments of one sort or another." (The correspondent promptly requested a date during the next school year.) Of course, the persons whom the Committee is likely to request for a speaking engagement are, unfortunately, rather active in many respects and consequently do have little spare time. Nevertheless, one of the gratifying aspects of LSC work is the generally gracious and considerate demeanor of celebrated personalities. While it may be said that great figures are in a position to partake of the luxury of eccentricity, a more important consideration appears to be that one who is truly great will be great in many ways.

Committee members are continually proposing schemes for procuring a larger number of stimulating speakers. A new idea for Tech was made possible by the Program Board of the Division of Humanities. This term the Committee will sell tickets for a subscription series of lectures to be given during the ensuing academic year. These programs will bring to M. I. T. some of the most significant figures of our time — a limited number of the famous personalities which LSC has most frequently been asked to obtain. It is expected that the usual semi-monthly events will continue.



At the rostrum, F. S. C. Northrup, Master of Yale's Silliman College and famous historian.

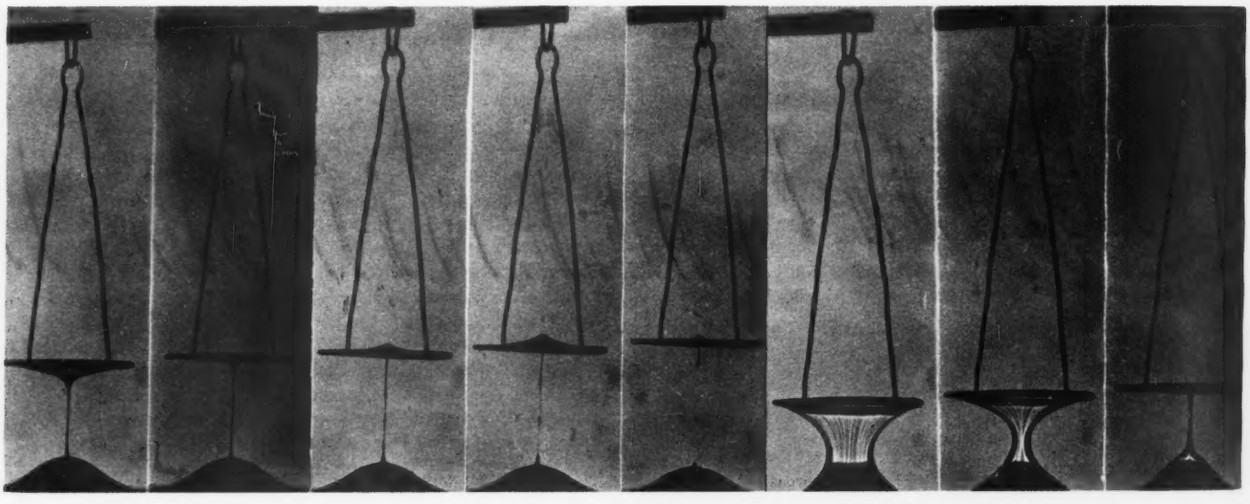


LSC'S lectures in 10–250 are usually quite well attended, particularly with speakers such as Dr. Urey.

the chemistry of neglected dimensions

By Kenneth King, Jr., '52

A new "world" was discovered in 1861 although few history books contain any mention of the event. Thomas Graham, an English chemist, was the discoverer and the greatest aids to his explorations were simply parchment bags and aqueous solutions. Naturally, this "world" differed quite a bit from the commonly accepted meaning of the word, but nevertheless it was quite a unique domain. In order to differentiate between the singular inhabitants of this "world" from those of any other, Graham designated them as colloids from "kolla" and "eidos" meaning "glue" and "alike" in Greek. Several decades later, the necessary and sufficient qualifications for a colloid were more clearly understood and the concept that colloids are nothing more than a state of matter has gradually evolved. Experimentation has substantiated that hypothesis and now it is generally agreed that *any* substance can be transformed into the colloidal state. More specifically, a colloid is said to be any substance which possesses at least one dimension falling within the colloidal range. This range covers the minute dimensions between 1/25,000 and 1/2,500,000, or from 1 to 1,000 millimicrons. Graham's "world" then has turned out to be a unique one, to say the least, in that it encompasses not a space in the universe but rather a specific range of dimensions.



These high speed photos show why the duNouy method for determining surface tension is not accurate for viscous liquids.

The colloidal range can probably be more easily visualized by considering an experiment and consequent observations not unlike those originally performed by Graham. Suppose one takes two bags composed of parchment paper and fills one bag with a water solution of ordinary salt and the other with a water solution of pure animal glue. Both of these solutions are clear and transparent, and even with the aid of a microscope one is unable to detect the presence of distinct particles. Each bag is then hung in a partially filled container of pure water so that the bag is partly immersed. After a while, the two bags are removed and the water in the containers is evaporated. In the container in which the bag containing sodium chloride was hung, one finds a residue of salt crystals; however, the water which surrounded the bag containing animal glue reveals no trace of any residue after the evaporation process has been completed.

Several significant conclusions may be drawn from this demonstration. Evidently, the glue particles are too large to pass through the fine pores of the parchment paper even though they were minute enough to escape detection by an ordinary microscope. The salt particles, however, easily passed through the paper in solution and were subsequently recrystallized on evaporation of the water. We may conclude then that the glue particles, which are of typical colloidal dimensions, must lie between microscopic ($>1\mu$) and molecular dimensions ($<1m\mu$) or in the colloidal range ($1m\mu-1\mu$).

Now that the term colloid has been partially clarified, one can more easily comprehend some of the various phenomena associated with matter in the colloidal state. As soon as one begins to consider those phenomena specifically related to matter in at least one dimension in the colloidal range, he has immediately touched upon that natural science known as colloid chemistry. In less general terms, colloid chemistry is actually the chemistry and physics of surfaces of which there is a preponderance of area over volume due to the very fine state of dispersion of colloids.

Colloids are easily distinguished from matter in other states of dispersion by their exceptional reactivity. This characteristic is, of course, a direct consequence of their tremendous ratio of surface to volume.

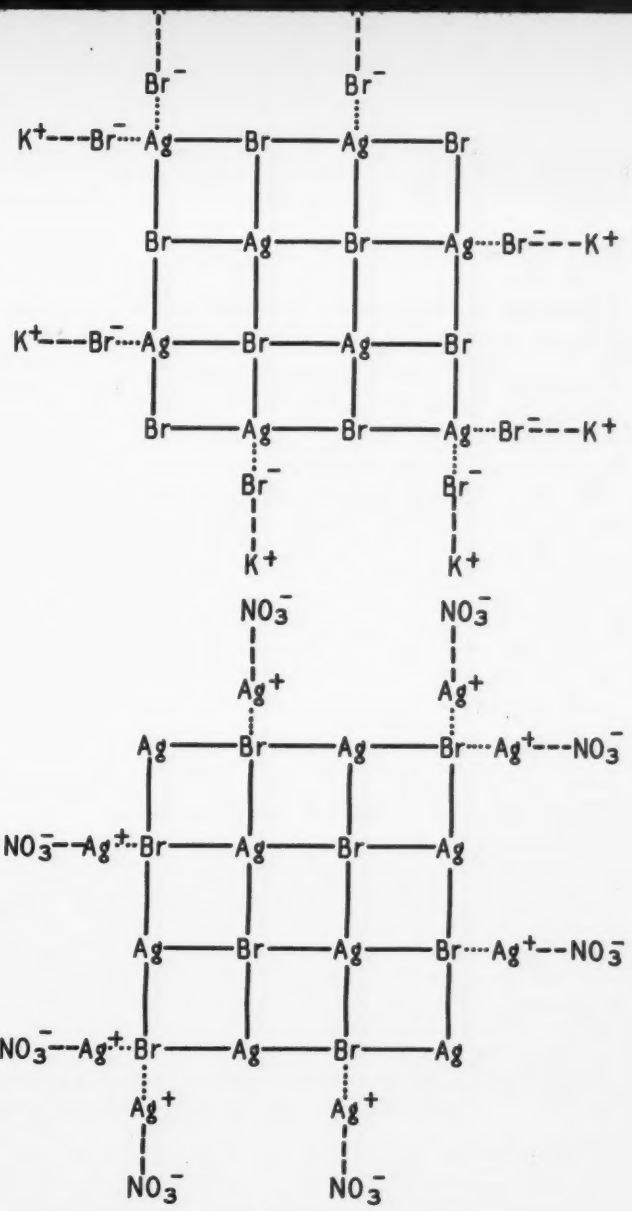
In order to demonstrate this fact, one can obtain a piece of charcoal and divide it into two pieces of equal weight. One piece is left in the original form and the other is ground to as fine a powder as possible. Then a strong aqueous solution of a dye such as methylene blue or crystal violet is prepared and equal quantities of it placed in two vessels. If one now places the piece of charcoal in one and the powdered form in the other, stirs well, and filters the two solutions through

filter paper, the two filtrates are strikingly dissimilar in appearance. Whereas the dye solution of the first container shows no perceptible change in color, uncolored water will come through filter from the glass containing the powder. This physical phenomenon, known as adsorption, is entirely dependent upon the great surface offered by the powdered charcoal.

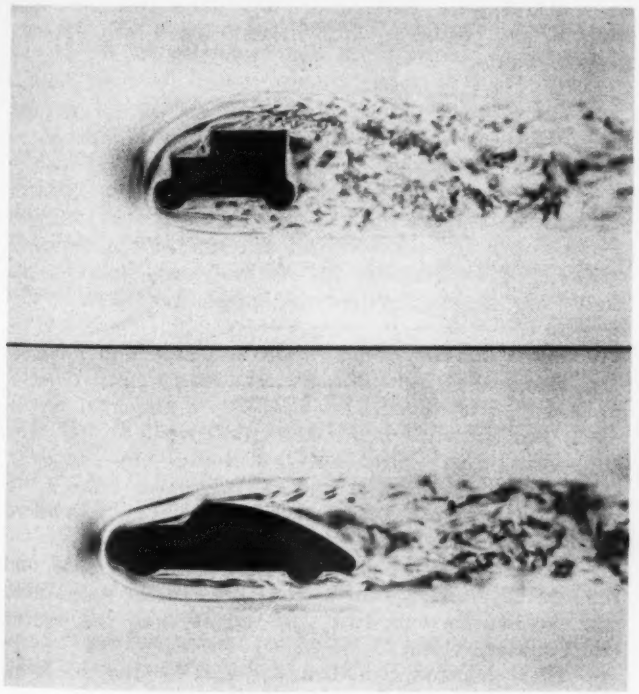
The determination of surface and interfacial tension is an important aspect of colloid chemistry. Many methods have been suggested for this purpose, but only a few have proven feasible for a large number of cases. The most versatile method of surface-tension determination known today is the pendant drop method, which is based on analysis of the forces acting on a static pendant drop. This method is one of the outstanding contributions made by colloid chemistry to theoretical science. The source of inaccuracy in employing the ring method or the duNouy apparatus for viscous liquids is clearly shown in Figure 1. The ring should pull up a cylinder of the liquid.

There are innumerable chemical phenomena which would be quite difficult, if not impossible, to explain if the properties of colloids were not understood. Recognition of the chemical unsaturation of ions located in the surface of matter as compared to those located in the interior is useful in explaining many of these.

As a specific example, let us consider the precipitation of silver bromide from solutions of potassium bromide and silver nitrate. If these are mixed in chemically equivalent proportions of medium concentrations, a crystalline precipitate will form and quickly settle. However, if the reaction is conducted with low concentrations and in the presence of an excess of either one of the reagents, a large proportion of the silver bromide formed will remain in suspension. A neutral particle of silver bromide is unstable and will cause the formation of a precipitate. If the reaction takes place in the presence of an excess of potassium bromide, however, then the active spots of the lattice structure of the silver bromide particle will satisfy their unsaturated, secondary valences by accumulating negative ions at the location of the positive silver ions in the particle surface. The equally unsaturated bromide ions do not attract positive potassium ions according to a specific law; there will be a trend to form the least soluble substance, i.e. AgBr and not KBr. This reaction produces a negatively charged particle which attracts the positively charged potassium ions as illustrated in Figure 2a. The ionic distribution resulting in the reverse case of the presence of an excess of silver nitrate is shown in Figure 2b. The particles then, although identical chemically, are quite different from a colloidal standpoint.



These drawings show the effect of surface charge on particles of silver bromide in excess potassium bromide and in excess silver nitrate.



A colloidal dispersion of clay in water is here used to demonstrate flow patterns around old and new models of automobiles.

For many years the great potentialities of colloid chemistry for aiding scientific and technological advances were substantially overlooked. The unusual phenomena observed in the classical demonstrations, however, gradually ceased to be merely laboratory curiosities and upon these a foundation of basic knowledge was built.

(*Continued on page 20*)

numbers

The Universe Reduced to an Equation

Brenton lurched across the table towards his two companions. "All right, so I can't prove it! So what? My being unable to produce a horse at the present moment doesn't rule out the possibility of there being such things, does it?"

There was a lapse of pained silence. Thomas righted the upset coffee cup and started to sop up the spilled coffee with his napkin. Hildebrand, who had been waiting for Brenton to "go off," expelled some cigarette smoke and watched it climb towards the ceiling.

"You know, Brenton, you may be right."

"Ah, after an hour and a half of bickering you finally admit that I 'may be right.' What do you mean 'may be right'? Of course I'm right. What do you think, Thomas?"

Thomas folded his coffee-soaked napkin.

"Well, like Hildebrand says, you may be ri . . ."

"Oh no, not you too!"

"Look," interrupted Hildebrand, "we'll assume you're correct. We'll assume that every function of nature *can* be expressed as a mathematical relationship. Furthermore, you say that all these various formulae can be derived from one general formula regulating the entire universe. Am I right so far?"

"Right!"

"In other words, if you could in some way discover the exact nature of that 'master' formula you could derive from it everything and anything in science."

"Exactly," beamed Brenton; "simple, isn't it?"

Hildebrand ground his cigarette into the ash tray.

"All you have to do now," he smiled, "is to work out that master formula."

Thomas poured himself another cup of coffee. "Easier said than done, no doubt."

"No doubt," agreed Brenton. "But that doesn't mean . . . "

"Yes, yes, I know," Hildebrand interrupted, "but suppose you were given the time. Say six months, say a year. How would you go about working out your formula?"

"Well . . . probably I'd spend the first six months — no — I'd need years. Yes, the first year would be spent in research. First I'd gather together all the significant available knowledge about nature, as expressed mathematically. Then it would take years to correlate them and see how they fitted together. It would be a tremendous job." Brenton's eyes glistened.

Hildebrand casually rummaged around for a cigarette. "Look," he said, "you're independent, no family, plenty of spare time and money. You're a mathematician; why don't you try it? Of course, I don't believe it myself, but . . . "

Brenton lurched across the table.

"Give me three years — no, five; and I'll do it!"

Thomas righted the upset coffee cup and began again, with Hildebrand's napkin, to soak up the spilled coffee. "Well, Brenton," he remarked, "we're going to miss you for the next decade or so."

Brenton slapped his fist on the table. "Why didn't I think of it sooner? It'll take years. But wait and see, Hildebrand, wait and see. Give me the time, and I'll find it."

It was some time after Brenton had left when Thomas turned to Hildebrand and spoke.

"Well, now you've done it."

"Oh, it'll be good for him. Retirement, like his, from active work, can kill a man. He's already beginning to get cranky. This little project will at least keep him going."

" 'At least' is right."

"You never can tell. Some of the most amazing discoveries are nothing but the by-products of an unsuccessful research job."

"Then you don't think he will find this 'master' formula, as you call it?"

"I doubt it." He looked askance at the cigarette smoke. "If he ever did the results would be devastating." He gazed at where the smoke had been. "But he won't."

"What do you mean — 'devastating'?"

"Think of the possibilities. If a man were to develop such a formula he would be able to see into nature itself. He'd comprehend this chaos we call life. He'd know the 'where,' the 'why,' and the 'how' of every apparent and hidden act of nature — of God." He twirled his cigarette on the ash tray edge. "You know, Thomas, I don't think that would be too good."

Thomas tilted back in his chair. "Omar Khayyam juggled his numbers for a long time. That was a good many centuries ago, but you should read his poetry. Quite a man, Omar."

"Uh," grunted Hildebrand, "you English profs are all alike. You can twist anything into poetry."

(*Continued on page 22*)

m. i. t. has switched to synchrotron

By Harry Smith

Photos by William Gorham

Squatting in 24–036 is one of the best examples of combined power, versatility and refinement of control in "atom smashers," M. I. T.'s recently completed synchrotron. The latest in a series of high-energy-particle accelerators originating with the cyclotron of Lawrence and Livingston in 1931, this type of accelerator is especially important because it offers for the first time sufficient energy (180 million electron volts are needed; this synchrotron is rated at better than 300 million ev) to produce mesons in quantity and because, incorporating the best features of the cyclotron and its immediate successor — the betatron, it enables the operator to control the homogeneity and the energy of the particle beam with hitherto unrealized delicacy.

It may be convenient to recapitulate the role of the particle-accelerator in physical science. For several decades, one of the major problems confronting the investigator has been that of determining the physical laws governing the composition and structure of the atomic nucleus. The classic method of solution is to bombard atoms with elementary particles — that is, neutrons, electrons, alpha particles, etc. — and to observe by cloud chamber photographs or some other suitable means the behavior of the atomic fragments which result from the impact.

Originally, these elementary projectile particles were obtained via radioactive decomposition, with consequent restrictions of particles few in number and weak in energy. The great kinetic energies are necessary because the atom, as we know it today, is a positive and very dense nucleus surrounded by an extended negative charge cloud of low density. The effect of this negative cloud is to very effectively shield the nucleus from any extraneous particles that might approach the atom. Indeed, if a projectile particle is not to be deflected completely ere it impact the nucleus, it must have an energy on the order of at least a few hundred thousand volts.

In 1931, at the University of California, Lawrence and Livingston developed their cyclotron along the following principles. A hollow metal disc is cut apart along a diameter and the two hemi-discs are placed between the pole faces of a magnet providing a uniform magnetic field. If a particle is caused to revolve circularly in the field of the magnet, and within the shielding space enclosed by the disc, and if a radio frequency oscillator causes one hemi-disc to have an alternating potential with respect to the other, then in each revolution the particle will receive two impulse accelerations. Since the frequency of revolution in a magnetic field is dependent upon only charge, mass, and magnetic field strength, the frequency of the oscillator need only be fixed at the proper synchronous value and the particle can revolve and become more and more energetic.

Unfortunately, the relativistic increase of mass over rest mass with increasing velocity makes the cyclotron particularly unsuitable for electrons, and generally unsuitable for most particles whose energy much exceeds the twenty million ev of Lawrence's cyclotron.

Kerst, of the University of Illinois, furthered the solution of this problem in 1941 with the betatron, a doughnut-shaped tube of porcelain placed once again between the pole pieces of an electromagnet. The magnetic field this time, however, is neither constant nor uniform. The change of magnetic flux is the accelerating agent for the particles revolving within the tube, and the non-uniformity of the field is necessary to restrict the path of revolution to a definite radius. The betatron is essentially a transformer in which the secondary winding is replaced by the accelerating electrons. With no need of synchronization between the period of revolution and a driving impulse, relativistic increase of mass is inconsequential, and the apparatus is especially valuable for the energizing of electrons. The two restrictions that arise, however, are the tremendous size of the magnet required — nearly one thousand tons for a three hundred million ev betatron — and the electromagnetic radiation by the accelerated electron, which thwarts a continued successful balance between the magnet's two functions of orbitizing and accelerating.

The three latest steps are embodied in the synchro-cyclotron — a positive particle accelerator in which the frequency of the oscillator varies so as to compensate for the mass change; the synchrotron — an electron accelerator in which the initial acceleration may be provided as in the conventional betatron and the final acceleration by an oscillator; and the bevatron — which accelerates protons in radial orbits.

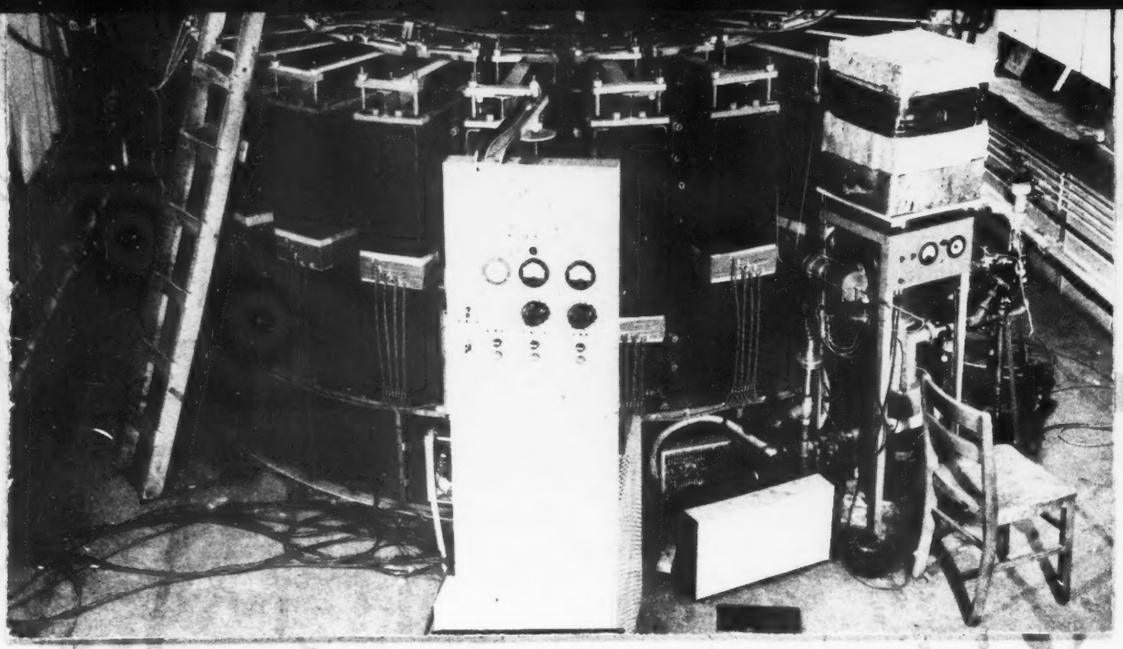
Let us examine the three hundred million ev synchrotron, as exemplified by the one at Tech.

Electrons are injected into a ceramic doughnut at fifty thousand volts and are accelerated radially by a weak magnetic field of eight gauss; the electromagnetic induction resulting as the field strength increases to two hundred gauss energizes the electrons to two million ev. So far this is no different from ordinary betatron operation. A radio-frequency voltage oscillator surrounding a gap in a segment of the tube ring is now activated to provide the synchronous acceleration.

If the magnetic field strength did not further increase (to a ten thousand gauss peak one two hundred and fiftieth of a second after the beginning of the cycle) but remained constant, the electrons would always pass the oscillator at a time when its impulse was zero. The increase in field strength, though, with its resultant increase in frequency of revolution causes the particles to pass the oscillator at such a time that the accelerating impulse voltage is not zero — in other words "out of phase." The faster the magnetic field is increased, the greater is this accelerating voltage and the greater is the energy gain of the electron for each orbital revolution. If certain operating limits are observed, this arrangement is quite stable and the source of acceleration cannot get out of step with the magnetic field.

When the three hundred million ev electrons are ready to be ejected from the doughnut, through a target aperture, by a propitiously timed interruption of the normal operating conditions, they have a mass six hundred times that of the rest mass. Usually, rather than use the particle beam directly, the operator has

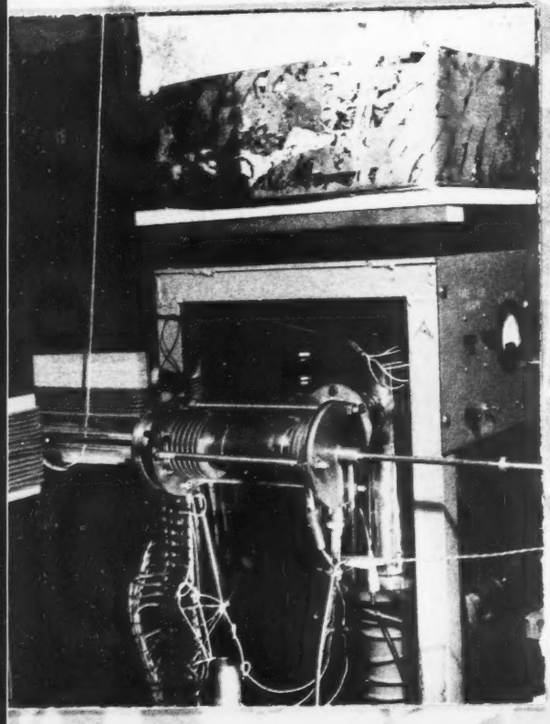
(*Continued on page 26*)

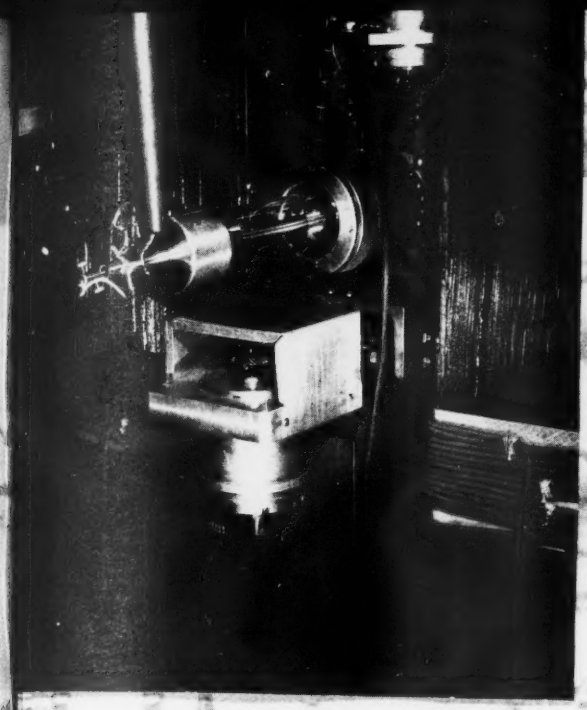


Front view of synchrotron. There are 24 C-shaped magnets weighing over two tons each.

A portion of the bank of capacitors required to supply the magnets with power.

This pump system maintains a vacuum of 0.001 micron.





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In this photo the gun is
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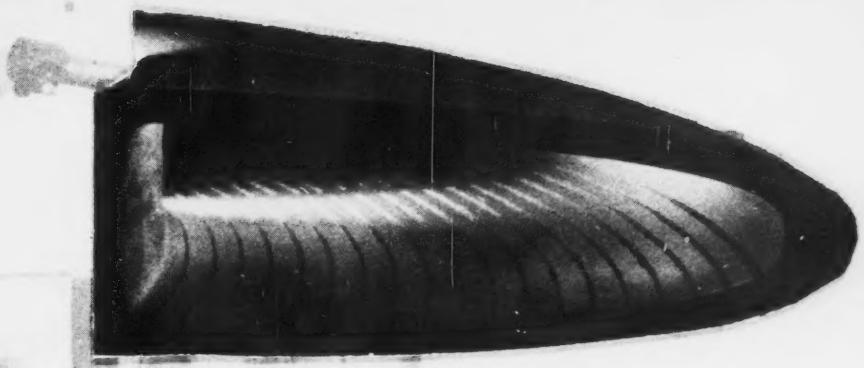
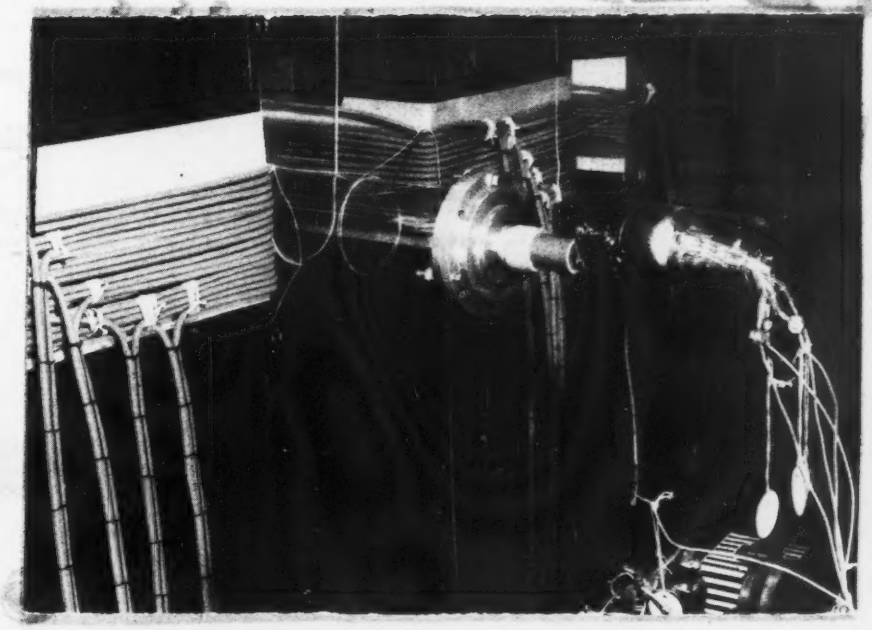
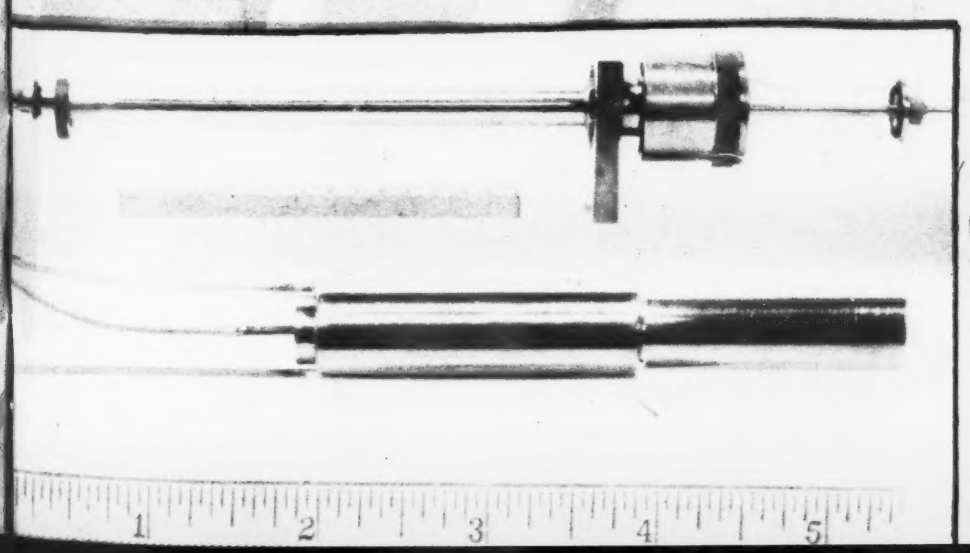


Cross section view of accelerator tube. It is often referred to as the "Doughnut."



View of correction coils for trimming magnet.



Details and construction of electron injector gun.

tech engineering news

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from the editor's notebook

Yes, but...

An interesting article, for all those who would like to know something about the policy of the Administration at Tech with regard to the balance between teaching and research, was printed in the February 13 issue of *Chemical and Engineering News*. Its author was Dean of Engineering, T. K. Sherwood.

In this article, Dean Sherwood stated a professor "who does no teaching has no more place on a university faculty than a teacher who has no interest in research." A professor, to inspire his students to creative effort, must not only teach, but he must create, himself, so that he knows whereof he speaks. This seems quite logical, and we heartily agree, so far as most courses throughout M. I. T. are concerned, but how about the freshman subjects?

It's hard to find many freshmen who cannot say of at least one instructor, "He knows his stuff so far as I can see, but he certainly makes it hard to understand." Freshman courses are difficult for freshmen and such comments are not therefore out of order. However, it might be some help, to those getting started in using basic tools, to have persons teaching the use of these tools experienced teachers, even at the expense of research.

What?!...

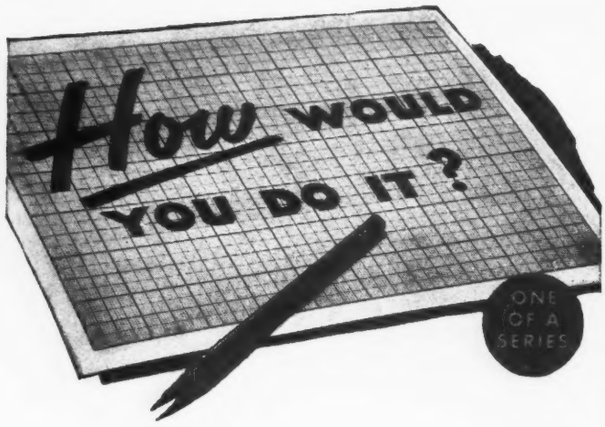
A recent issue of *Scientific American* printed a description of a public hearing on vivisection held in Baltimore. The question under discussion was the use of stray dogs for medical purposes. When one mother, whose child had undergone the "blue baby" operation (developed in experiments with dogs), asked the audience whether it preferred to save babies or dogs, several persons shouted, "Dogs! Dogs! Save the dogs!" If the story is true, it's totally beyond our comprehension.

Football?...

Last month, the question of a varsity football team for Tech came up in Institute Committee. Those who backed the idea are hoping for a team which will compete with schools such as Worcester Polytech, but some may ask, "Even if we are not playing in the Ivy League, wouldn't the time required for practice and allied activities take more time than those involved could afford?" The answer seems to be, "No." We are told that at Worcester, the football team puts in two and a half hours a day in practice. Let it be pointed out that the local crew puts in an equal amount of time in season.

Assume that Institute Committee passed the suggestion along to the Corporation and that body O. K.'d it. What would be used for a stadium? It is quite possible that the stands at Briggs Field would do, but if so let's forget the whole idea. A school of four thousand undergraduates should be able to supply more than several hundred to watch a varsity football game.

K. K.



PROBLEM—You are designing an electric clock for automobiles. The clock itself is completed. To set the clock, the spindle which turns the hands must be pushed in against a spring pressure and then turned—and, of course, when the clock is installed, this spindle is back under the dashboard. You want to provide a means for pushing and turning the spindle from a point that is easy to get at. How would you do it?

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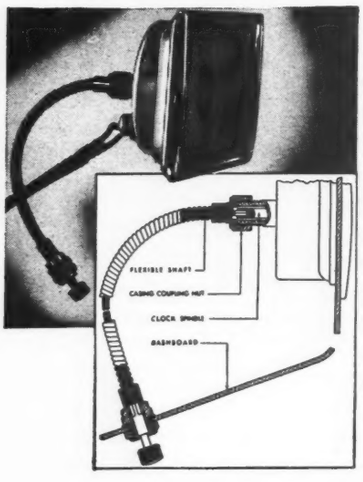

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the chemistry of neglected dimensions

(*Continued from page 13*)

This knowledge, in turn, has been applied to such fields of endeavor as medicine, theoretical science, and industry. Up to the present time the results have proved quite gratifying, and even greater advances are expected to be forthcoming. Let us consider a few specific applications of colloid chemistry to medicine, theoretical science, and industry.

One significant contribution made by the colloid chemist to the medical profession has been an explanation of the mechanism of silicosis. This disease has undoubtedly shortened the lives of thousands of persons during the past centuries and is characterized by the presence of silica in the lungs. There have been several theories advanced as the cause of silicosis in the last eighty-five years. One explanation, known as the "mechanical theory," was based on the idea that the abrasive actions of the sharp silica particles on the lung tissue caused the damage. This theory was disproved in 1923 when it was shown that carborundum dust, a substance with much harder and just as sharp edges as silica dust, did not produce harmful effects in the lungs of test animals. Another theory, the "solubility theory," was based on the vague assumption that solubilized silica acted as some sort of chemical poison itself. This seemed rather illogical since silica is so widely distributed that it is constantly taken into the body throughout one's life. Then, a new approach was made to the unsolved problem by the colloid chemist. He considered one fact which any "standard" chemist would have overlooked, namely the exceptional reactivity of fresh silica surfaces. By applying the principle of crystal chemistry and polarization of ions to the atomic structure of the surface of colloidal silica, he finally came up with the solution that atomic oxygen is formed at the surface which acts like ozone and therefore must be considered the poisonous agent.

In a more theoretical application, colloids have proved to be of great aid in determining flow patterns and hence in "streamlining." In Figure 3a and 3b a colloidal dispersion of bentonite enables one to observe the comparative degree of turbulence caused by the motion of old and modern automobile models.

It would, of course, be impossible to mention all of the industrial applications of colloid chemistry because of their great number already in use and the many additional ones in their incipient stages. However, when one realizes that the natural rubber, synthetic rubber, plastics, ceramics, paper, and paint industries are all directly based upon the processing of colloidal materials, one begins to appreciate the magnitude and importance of colloidal applications. Also, many operations such as catalysis, solvent recovery, mixing, and emulsification are common to any number of different types of industries and are based upon colloidal phenomena.

Since so many previously unsolved chemical and physical phenomena have been explained satisfactorily in colloidal terms and applied industrially, is it not plausible to think that many more equally significant phenomena may succumb to the methods of colloid chemistry? Because of the increased emphasis upon the employment of colloid principles, it is becoming more and more imperative that chemists and chemical engineers have at least a basic knowledge of it. Colloid chemistry is ceasing to be the chemistry of the "world of neglected dimensions." It is truly becoming the chemistry of the "world of invaluable dimensions."

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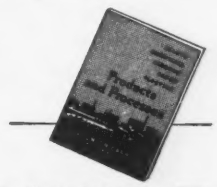

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numbers

(*Continued from page 14*)

"Uh," mocked Thomas, "you mathematicians are all alike. You can twist anything into formulae."

* * * *

Hildebrand waited; then dropped the telephone back into its cradle. He frowned, stuck his hands deep into his pockets, then shrugged his shoulders and picked up the phone again. He dialed and looked pensively out the window at the traffic below.

"Hello, Thomas? Listen, I just got a phone call from Brenton. . . . What? Yes, about three minutes ago. . . . Why don't you come up about eight tonight? We'll go over together. . . . Yes. . . . Goodbye."

It was ten o'clock when Hildebrand and Thomas arrived at Brenton's house. Located in the country, it had been, at one time, a rather impressive structure. Now, beneath the starlight, the lawn lay matted with goldenrod and milkweed. The front walk was split and cracked by tall grass.

Hildebrand rang impatiently, banged the door knocker and waited. Finally he shook the door. It opened. He stepped in and shouted.

"Brenton!"

There was no answer.

He tried again, "Brenton!"

Silence. Hildebrand grunted and had started to fumble for the light switch when Thomas touched his arm and whispered to be quiet. Piano music was reeling out from behind a closed door somewhere in the house. Hildebrand flipped the light on.

For the first time they were able to see their surroundings. The hallway was a jungle of cardboard and wooden boxes. They walked single file between walls of crates and packing cases, some empty, some full of books; all were covered with an even layer of dust. They wandered through the first floor trying to locate the source of the music. In every room the scene was the same; each was a field of books, about waist high, through which was a crooked alley. They reached the stairs and began to climb.

Hildebrand walked ahead, sweeping the air with his hat, tangling with spider webs, while Thomas followed, rummaging in the crates, opening books, and coughing from the dust he upset. The music was louder now. Hildebrand climbed two more steps and turned down a passageway. A scratchy recording of Beethoven trickled out with a stream of light from under a door at the end of the hallway.

Hildebrand knocked.

"Brenton! Brenton!"

No answer, just the continuous flow of notes. He pushed open the door.

The large room was a sea of books. On either side of the doorway tall stacks leaned towards each other. The floor was waist deep in books and a narrow alley of yellowed newspapers ran a crazy zigzag around a central mountain of crates and boxes. In one corner a metal filing cabinet, half its drawers missing, twisted beneath stacks of paper. The light and music were coming from the other side of the boxes. Hildebrand gingerly picked his way around.

A sudden voice took him by surprise.

"My visitors! Sit down and listen to the music. Nothing so relaxing as a Beethoven sonata. Beautiful, isn't it?"

Thomas sagged against a tower of notebooks and said nothing. Hildebrand stared.

Brenton lay propped up on a filthy cot, a torn sheet

across his legs. He wore a gray undershirt, sweat rings of dirt ran around his neck, and he was long unshaven. Much of his hair had fallen out and strings of it lay on the pillow. On his night table was a yellow bottle of milk and an electric plate. One corner of the floor was piled with tin cans. On a large packing case, he had set up the record player which still continued to grind out chords.

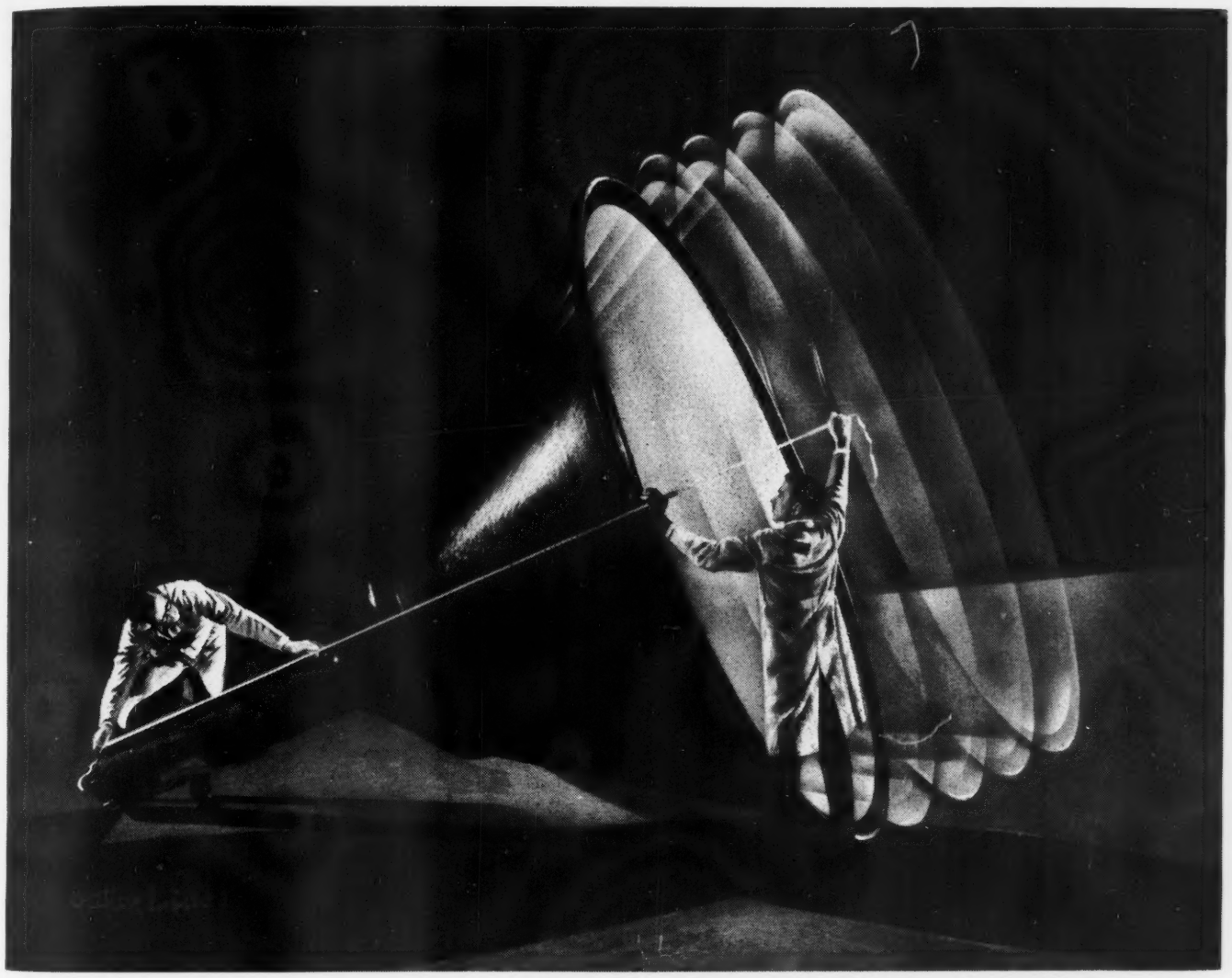
Thomas cleared his throat; he spoke just above the noise of the victrola. "We've tried to see you before but your housekeeper said . . . "

"Yes, I know. It was just a precaution to insure some solitude while I worked on my project. Poor Mrs. Wells. She stuck with me for almost eight years before she became convinced that I was crazy." He laughed, revealing an irregular row of discolored and missing teeth.

"What have you done to yourself?" asked Hildebrand.

The arm reached the end of the record. Brenton picked it up and set it back at the beginning again. "Sshhh," he whispered, "listen to the music . . . nothing like a Beethoven sonata . . . I've got other records

(*Continued on page 24*)



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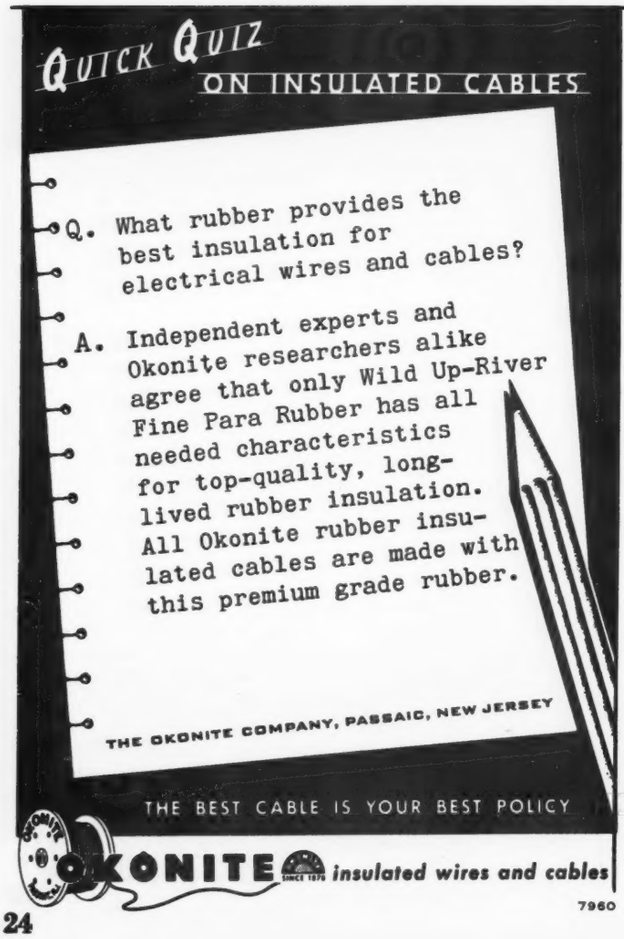
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numbers

(*Continued from page 22*)

downstairs, but I like this one . . . beautiful, isn't it?"

Hildebrand was getting nervous.

"Brenton, get up. You're coming with us."

"Oh, no," he sighed. "I'm staying here to listen to my records. When you leave, take that stack of papers with you." He pointed to a neat bundle on the desk by the foot of the cot. "And now, Beethoven."

"Brenton, get up. Come on!"

Brenton smiled and closed his eyes.

"Let's go, Thomas. We — let's go." He tucked the bundle of papers under his arm and made his way out to the door. Thomas followed.

The record wound down to its end. Brenton set the player arm on its catch, reached over, shook open the night table drawer and took out a bottle of small pills. He poured himself a glass of water and methodically washed down all of the pills. Then he reached over, set the needle on the record, and waited. Over the scratching came the familiar rumble of chords, then the worn melody. Brenton lay back and closed his eyes.

* * * *

"The whole thing is ridiculous," murmured Thomas. "Pathetically ridiculous. What did you find in those papers of his? Anything significant?"

Hildebrand lit a cigarette. "One sure thing," he paused to exhale, "no matter what Brenton's condition was when we found him up there in that hole, he was perfectly sane when he did that work. I can't understand why he committed suicide. When those doctors we sent up there found him he was cold; rotting away on that cot of his. I'd like to know what got into him."

He shrugged and continued. "As for those papers, they're the work of a genius. Clear, and what logic! He tosses out our entire system of numbers. This new arrangement he uses makes our scalers and Cartesian stuff look as clumsy as Roman numerals."

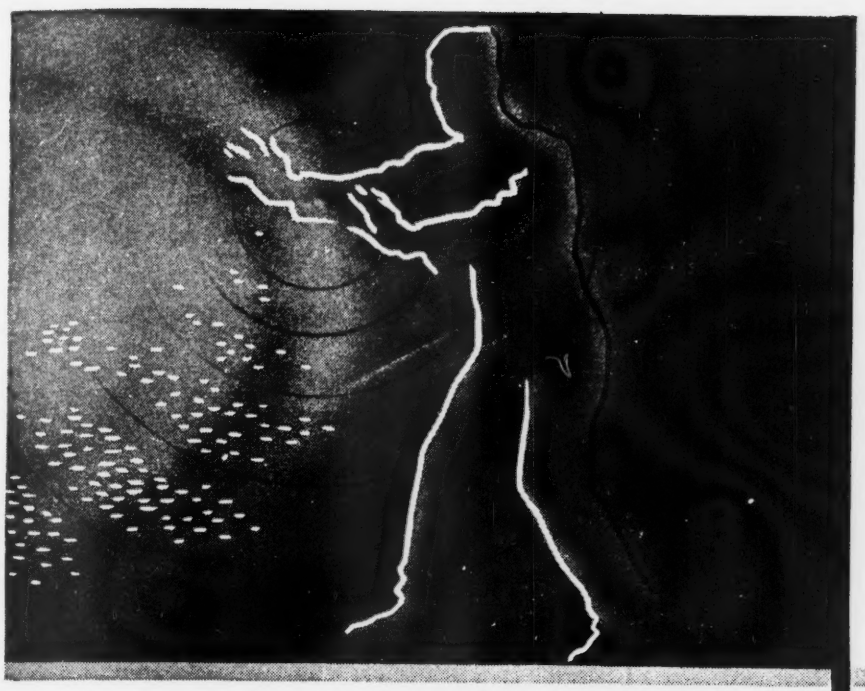
He squinted through a cloud of smoke. "Even if he hadn't done anything else this 'K' system, as he calls it in his papers, would have netted him a good bit of fame. It's beautiful. No square root of minus one, no vectors, no indeterminate forms; the thing is sheer logic. It fits together like nothing I've ever seen."

"What about the formula?"

"Ah, that thing. I don't know yet. He takes five pages of notes just to explain the terminology. Uses a new set of symbols, has to." He paused. "It has tremendous implications." He fell to thinking.

Thomas brought his hands slowly together, constructing a globe by touching his finger-tips lightly to one another. He was silent for a while, then he broke out with, "I don't like it. The whole idea, I just don't like it, that's all. It's unhealthy. It makes my skin crawl to think of it. A 'master' formula, the universe plotted on a piece of paper, the fate of man in an equation." He stared at the floor.

(*Continued on page 26*)



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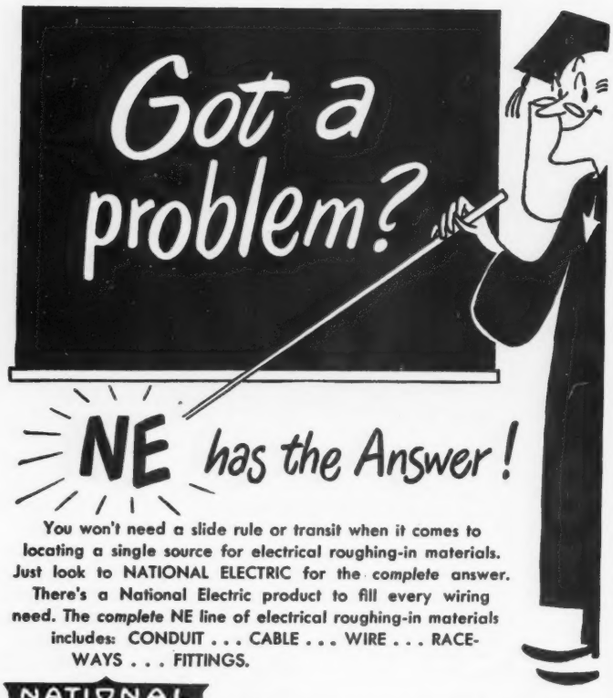

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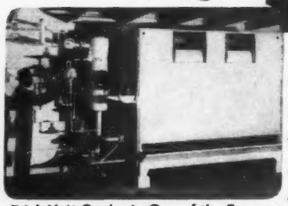
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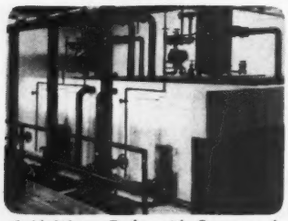
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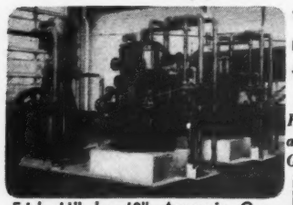
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(*Continued from page 15*)

it impinge upon a tungsten target to produce X-ray pulses which are ten millionths of a second in duration. This energy synchrotron requires a fifty-five ton magnet of special construction-sheets of transformer steel each only 0.014 inch thick. In addition, for power it is necessary to store energy from the power mains in a huge capacitor bank (the one at Tech is one of the world's largest — thirty-three kilovolt-amperes, or eight hundred microfarads at fifteen thousand volts), whence it is released as needed by an electronic switch. The single cycle of current (four thousand amperes), which flows at a peak of fifteen thousand volts, produces a circulating power in the magnet of nearly sixty million volt-amperes — the equivalent of that generated by 1,200 large radio stations.

numbers

(*Continued from page 24*)

"Shake it, Thomas, you're getting depressed. We've got something big here. Probably the greatest thing that has ever happened to mathematics, or the world, is wrapped up in that final equation."

He arose to go . . . "I'm going to put in some close study on the last phase of this thing. But drop over in about a week. Everything should be set by then."

That was Sunday night. Thursday, at one in the morning, Thomas received a call. Hildebrand had committed suicide by leaping from his sixth-story study-room window.

* * * *

Thomas sat down, stretched his legs towards the glowing fireplace, and regarded the stack of papers at his elbow. He fingered the rotted pieces of paper. Rain had blown into Hildebrand's apartment that night three years ago, and several of the last pages were warped and streaked. He wondered what was revealed in that final equation which caused both men to commit suicide.

The whole thing was blasphemous, he thought. No good could ever come of this playing around with nature. That was the trouble with scientists, they didn't know when to stop. His mind wandered on. He took a thick handful of the papers and dropped them into the fire. For a few seconds they remained unchanged, the edges slowly browning. Then they buckled and burst into flame. The remaining pages he let drop by ones and twos, watching them spiral and dissolve in the fire. He stared at the last five papers, then let them slide from his hands into the grate. The last sheet circled over the flames, swung up, then dropped on the edge of a glowing pile of embers.

It was, he realized, the page containing the expression which Brenton had spent eight years in deriving. He saw the symbols and the terse connecting words. His eyes jumped to the long equation that unwound across the paper. A man might hold the world in the palm of his hand, if only . . . The paper writhed as though it were in agony. A man might hold the . . . Thomas dropped to his knees and snatched at the collapsing sheet.

Bits of black ash puffed up between his fingers. He paused for a long time, then rose to his feet, slapping his palms together. He kicked a few dead embers back into the grate, and replaced the fire screen. Thomas looked at himself in the mirror above the mantle. He straightened his necktie. Thomas took one last look at the dead fire and, turning, went upstairs to bed.

Electronics

GLAMOUR GIRL—OR PRODUCTION WORKER?

by H. A. BARTLING
Manager, Electronics Section
General Machinery Division
ALLIS-CHALMERS MANUFACTURING COMPANY
(Graduate Training Course 1927)

SO MANY near-miracles, actual, experimental or imaginary, are being attributed to electronics that it's quite the glamour girl of the electrical industry. Working closely with this infant prodigy, we find it is indeed fascinating and astonishingly versatile. We find, too, that it is a terrific worker. Applying electronic principles to tough, matter-of-fact industrial jobs is the work of this section.

H. A. BARTLING

It rewards us with some really amazing success stories, and with abundant opportunity. The field has hardly been touched.

New Field

This field of industrial electronics was completely unknown, of course, when I received my degree in Electrical Engineering from Illinois and entered the Graduate Training Course at Allis-Chalmers in 1925. During the 2-year course I stuck pretty close to electrical work—and at its completion, I was on the electrical test floor helping run tests on some of the first big blooming mill motors the company ever built.

Next, I worked in the Basic Industries Department on electric mine hoists. In 1931, I moved back to the Electrical Department, doing sales application work for the Motor and Generator Section. I worked, successively, on unit sub-stations, had charge of the Mixed Apparatus Section, was in Industrial Sales, handled contract negotiations and sales liaison work during the war, and in 1947 took charge of the company's growing Electronics Section.

Massive castings for a 60-inch Superior-McCully crusher being assembled in the A-C West Allis plant. Machine will reduce 5-foot boulders to crushed rock—handle 2500 tons of ore per hour!

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Wide Choice of Interests

I've traced this brief personal history to illustrate the widely varied opportunities a young engineer finds at Allis-Chalmers even within a single field such as electricity. I never got far from the Electrical Department, because I found what I wanted right there. But I wouldn't be giving a true picture of Allis-Chalmers if I didn't touch on the other great departments, covering just about every major industry.

Many GTC students find their greatest interest and opportunity in the Basic Industries Department. There they design, build and install the machinery for mining, smelting, cement making, flour milling, oil extraction, food and chemical processing. Others become interested in hydraulic or steam turbines, the complexities of centrifugal pumps and the engineering problems of small motors or V-belt drives.

Some fit into engineering and design. Some find themselves most interested in manufacturing or in field work such as service and erection. Many like selling, and find their engineering training pays off best in a District Sales Office.

Whatever a man may eventually find most to his liking and advantage, the Allis-Chalmers Graduate Training Course is a wonderful vantage point from which to start. It offers contact with all major industries, and a chance at many types of work: design, manufacture, research, testing, installation, selling, advertising, export. There is no other organization that can offer a graduate engineer such a wide range of activities.

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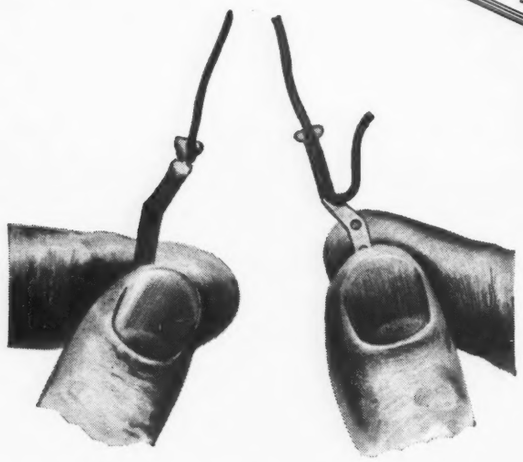
Newsworthy Notes for Engineers



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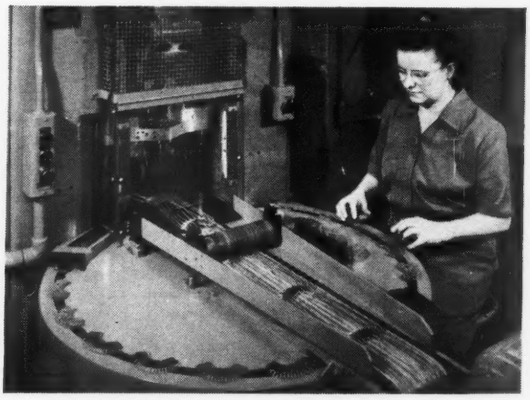
$2,500,000 a year!

Both hands hold terminations used in telephone dial switching equipment. They look pretty much alike – but let's see about that!

The termination at left is made by the old method. Insulation is stripped off the wire. The wire is twisted around the brass terminal, then fastened to it with a soldering iron. That had to be done on millions and millions of connections each year.

The termination at right is made by a new machine process developed by engineers at Western Electric–manufacturing unit of the Bell System. One type of machine separates the brass connectors from a "strip" and accurately positions each on an insulator to which groups of 10 are fastened by eyeleting. Another machine places 20 wires in the proper position on two sets of 10 connectors, drives two small pyramidal shaped points through the insulation into the wire and crimps the brass around the wire, making a good, solid electrical connection. The whole job now is done in one-tenth the time.

This improvement will add $2,500,000 a year to the vast amount Western Electric engineers are saving the Bell Telephone System through manufacturing economies. Year after year they look for – and *find* – ways to make telephone equipment better and at lower cost. Their savings help Bell Telephone companies to keep rates as low as they are.



This machine, developed by Western Electric engineers, assembles dial switching terminations automatically at the rate of 400 per minute.

Western Electric

A UNIT OF THE BELL SYSTEM SINCE 1882

Engineering problems ***are many and varied at Western Electric, where manufacturing telephone equipment for the Bell System is the primary job. Engineers of many kinds—electrical, mechanical, industrial, chemical, metallurgical—are constantly working to devise and improve machines and processes for production of highest quality communications equipment.***

Strength factors of Long Life!

No pipe that is provably deficient in any of these strength factors should ever be laid in city streets

SHOCK STRENGTH — The toughness of cast iron pipe which enables it to withstand impact and traffic shocks, as well as the hazards in handling, is demonstrated by the Impact Test. While under hydrostatic pressure and the heavy blows from a 50 pound hammer, standard 6-inch cast iron pipe does not crack until the hammer is dropped 6 times on *the same spot* from progressively increased heights of 6 inches.

CRUSHING STRENGTH — The ability of cast iron pipe to withstand external loads imposed by heavy fill and unusual traffic loads is proved by the Ring Compression Test. Standard 6-inch cast iron pipe withstands a crushing weight of more than 14,000 lbs. per foot.

BEAM STRENGTH — When cast iron pipe is subjected to beam stress caused by soil settlement, or disturbance of soil by other utilities, or resting on an obstruction, tests prove that standard 6-inch cast iron pipe in 10-foot span sustains a load of 15,000 lbs.

BURSTING STRENGTH — In full length bursting tests standard 6-inch cast iron pipe withstands more than 2500 lbs. per square inch internal hydrostatic pressure, which proves ample ability to resist water-hammer or unusual working pressures.

Without shock strength—or, for that matter—without all of the strength factors listed opposite—no pipe laid 100 years ago in *city streets* would be in service today. But, in spite of the evolution of traffic from horse-drawn vehicles to heavy trucks and buses—and today's vast complexity of subway and underground utility services—cast iron gas and water mains, laid over a century ago, are serving in the streets of more than 30 cities in the United States and Canada. Such service records prove that cast iron pipe combines all the strength factors of long life with ample margins of safety. No pipe that is provably deficient in any of these strength factors should ever be laid in city streets. Cast Iron Pipe Research Association, Thos. F. Wolfe, Engineer, 122 So. Michigan Ave., Chicago 3.

CAST IRON

CAST IRON PIPE SERVES FOR CENTURIES

briefing the news

Move Mountains? . . .

A microwave communications system recently installed between a substation and power generating plant in Pennsylvania has shown reflection of microwaves to be both efficient and economical. The station and generating plant were fitted with microwave communications because the expense of multiple telephone lines would have been considerable. However, microwaves travel only in a straight line, and there was a hill between the two points to be connected. Since the waves would not go over or through the hill they were reflected around it.

In operation, the microwaves are beamed at a large aluminum reflector sheet placed two miles from the substation. The twenty-foot square sheet is in the line of sight from both substation and generating plant and bends the beam around the mountain.

Synthetic Mica . . .

As a part of a broad program of research on fluorine-type artificial minerals being carried on at the U. S. Bureau of Standards, synthetic mica, with the same properties as natural mica but able to withstand higher temperatures, has been crystallized successfully.

Mica could be synthesized by duplicating the conditions under which it is naturally formed, but this would require unduly high pressures and temperatures. Therefore fluorine was used, in the form of a fluorosilicate, to seed the crystal growth. Quartz, magnesite, bauxite, and the fluorine compound are placed in a platinum-lined crucible and heated to about 1400° C. As the mix cools, mica crystals form from a seed crystal.

Electrical measurements indicate a dielectric constant of about 6.3. The largest crystal grown in this research had an area of about four square inches.

Due to the high demand for mica in electrical equipment and the fact that the United States produces enough of the mineral for about only one-third of its requirements, research in this field fills a very definite need.

Cutting It Thin . . .

A General Electric researcher has made what may be the thinnest slice ever produced. This slice, a piece of metal less than two-millionths of an inch thick, was cut by a shock wave formed in the sample ahead of a knife blade moving with the speed of sound. The slicing device, called a high speed microtome, was developed for use in conjunction with electron microscope work.

Although specimens for light microscopes need never be cut thinner than thirty-millionths of an inch, the hundred-fold more powerful electron instrument requires thinner samples. Using the shock-wave technique, it has been possible to make very thin slices of everything from delicate animal and plant tissue to teeth and metal. Conventional microtomes, it has been stated, cannot make slices thinner than one-half the radius of curvature of their blades and it is doubtful that a blade exists with a sufficiently small radius of curvature to make the ultra-thin slices.

The actual high speed microtome consists of a delicately balanced metal wheel, spun at 65,000 r.p.m. by a three horsepower motor. Projecting one-half inch beyond the wheel's edge is a small steel blade which is driven through the air at speeds up to 750 miles an hour. A screw device feeds the specimen, embedded in wax, into the path of the knife. Since the shock wave in the sample makes the slice before the blade can cut, the blade's sharpness is not of primary importance.

New Counter . . .

Split-second flashes of light, produced when radioactive particles strike a prepared surface, may now be measured with great accuracy by an electronic counting system.

The scintillation counter which embodies this principle consists essentially of a phototube "eye" and a fluorescent screen or phosphor crystal. When the instrument is exposed to radiation, particles strike the screen and produce flashes of light. The light from each flash is picked up by the phototube and converted to a tremendously amplified electrical signal. The signals are then further amplified and registered on a suitable device to indicate strength of radioactivity in the area.

The heart of the counter is an electron tube known as the multiplier phototube. This photo-electric instrument picks up even feeble phosphorescent flashes and converts them to electric current, which is amplified as much as a millionfold before it is released to the other circuits of the instrument. The tube is capable of discriminating between flashes which arrive less than one 100-millionth of a second apart.

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NEWS

PIPE with WINGS

TONS of high pressure, high temperature piping in a power plant must "float" . . . or something busts. In a power station now under construction the main steam lines carry steam at 1,050 degrees temperature and 1,500 pounds pressure, and travel as much as 7⅝ inches vertically and 5 inches horizontally. If this expansion were to crowd back into any part of the power equipment, the strain would be disastrous.

At every point of its travel from cold to hot positions, this piping must have the same amount of support or "lift" so that none of the stress will be transferred along through the piping system. That's an engineering problem for which there's only one practical solution . . . what amounts to "wings for pipe". It's a constant-support pipe hanger, made only by Grinnell, which provides supporting force equal to the weight of the shifting pipe in all positions.

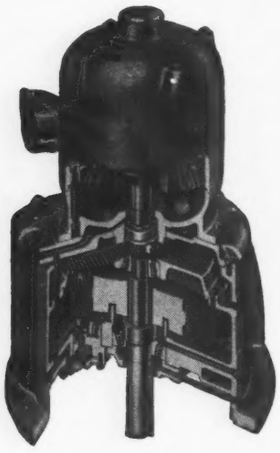
The solution to this complicated problem of thermal movement is typical of Grinnell's complete piping service, which provides the products, facilities and experience required "whenever piping is involved". Grinnell Company, Inc., Providence, R. I.

»»»» This is the largest Grinnell Constant-Support Hanger made. It is over 6 feet long and will handle vertical piping travel up to 8 inches and weights up to 22,000 pounds. Each of these mammoth hangers in this new power plant will support tons of chrome molybdenum alloy steel pipe with an outside diameter of 14 inches and a wall thickness of 2 inches through a maximum travel of 7⅝ inches vertically and 5 inches horizontally.

GRINNELL

ENGINEERING GRADUATES HAVE FOUND ATTRACTIVE OPPORTUNITIES WITH GRINNELL

Another page for **YOUR BEARING NOTEBOOK**

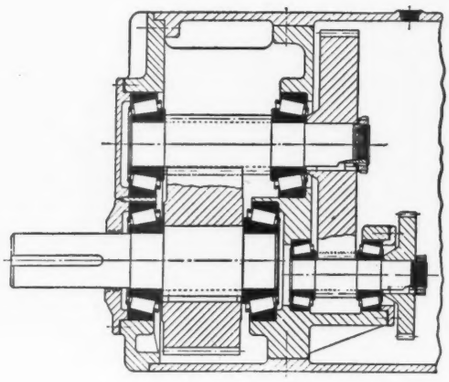


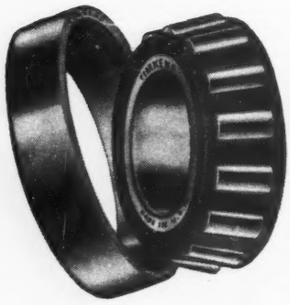
How to help a gearmotor take care of its teeth

To minimize wear on the teeth and to insure smooth, quiet operation, reduction gears in motors like this must be held in perfect mesh, no matter what the load. That's one reason why engineers mount the gear shafts on Timken® tapered roller bearings. Timken bearings hold the shafts in accurate alignment. Gears are kept perfectly positioned, with each tooth meshing smoothly and carrying its full share of the load.

Gears mesh smoothly, wear longer, with shafts on TIMKEN® bearings

Here is a typical gear-case countershaft showing a common method of mounting Timken bearings. Due to the line contact between the rolls and races, Timken bearings give the shaft maximum support. There's less chance of deflection under load. The tapered bearing design takes both radial and thrust loads in any combination. End-movement of the shaft is kept to a minimum. Gears wear longer—work better.





TIMKEN

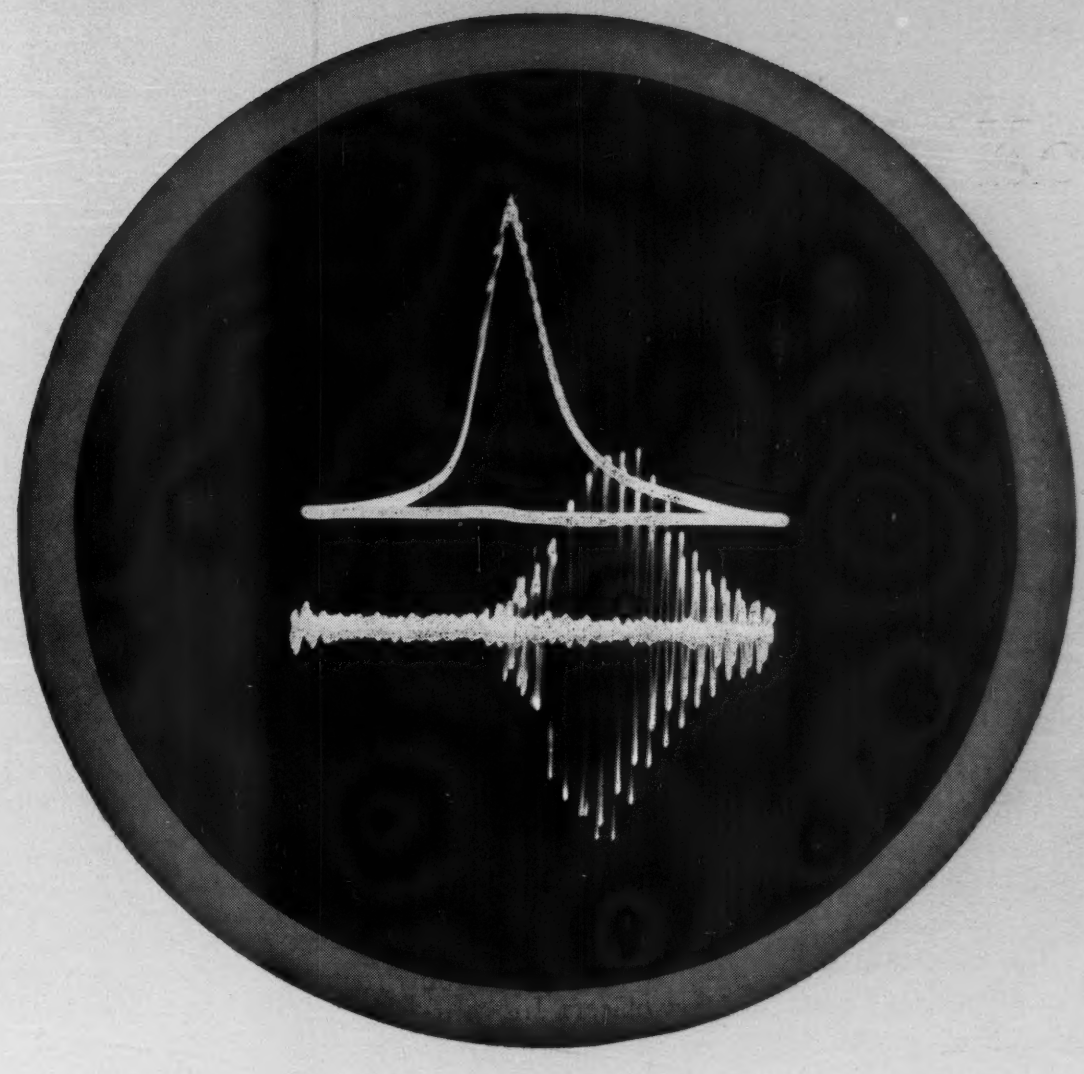
TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

Want to learn more about bearings?

Some of the important engineering problems you'll face after graduation will involve bearing applications. If you'd like to learn more about Timken bearings and how engineers use them, write today to The Timken Roller Bearing Company, Canton 6, Ohio. And don't forget to clip this page for future reference.

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◐ AND THRUST ⊣◐⊢ LOADS OR ANY COMBINATION ✳



This is a picture of "PING"

It's a picture that gives automotive engineers clear-cut facts on performance—a picture that suggests how photography with its ability to record, its accuracy and its speed, can play important roles in all modern business and industry.

No, this is not the "doodling" of a man on the telephone. Far from it. It's the photographic record of an oscilloscope trace that shows, and times, detonation in a "knocking" engine. It all happens in a few hundred-thousandths of a second—yet photography gets it clearly and accurately as nothing else can.

Oscillograph recording is but one of countless functional uses of photography in bettering products and improving manufacturing methods. High speed "stills" can freeze fast action at just the crucial moment—and the design or operation of a part can be adjusted to best advantage.

And high speed movies can expand a second of action into several minutes so that fast motion can be slowed down for observation—and products be made more dependable, more durable.

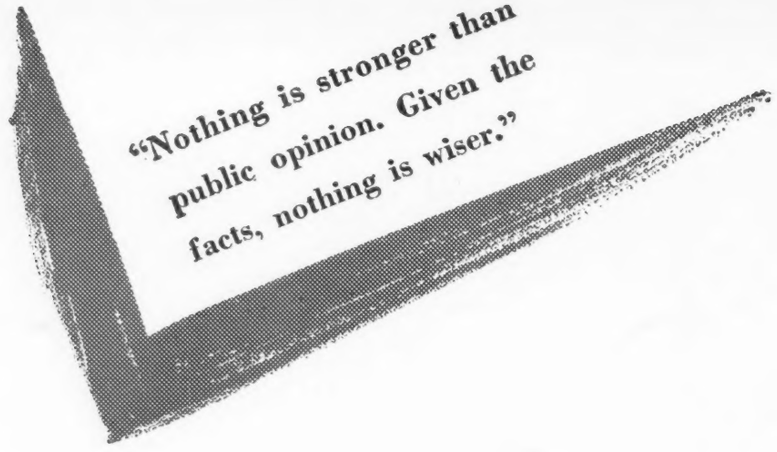
Such uses of photography—and many more—can help you improve your product, your tools, your production methods. For every day, functional photography is proving a valuable and important adjunct in more and more modern enterprises.

Eastman Kodak Company, Rochester 4, N. Y.

Functional Photography

. . . is advancing business and industrial technics

Kodak
TRADE-MARK



On Competition

Hatch a good idea and you hatch competitors.

It works this way—to take General Electric as an example:

In 1934, the automatic blanket was initially developed by General Electric. Today there are twelve other companies making electric blankets in competition with G. E.

In 1935, General Electric first demonstrated fluorescent lamps to a group of Navy officers. In 1938, the first fluorescent lamps were offered for sale. Today they are being manufactured by a number of companies.

The first turbine-electric drive for ships was proposed and designed by G-E engineers. Today four companies in this country build this type of ship-propulsion equipment.

After several years of laboratory development, General Electric began production and sale of the Disposall kitchen-waste unit in 1935. Today fourteen other companies are in this field.

The first practical x-ray tube, developed at General Electric years ago, is now a highly competitive business for seven manufacturers.

In 1926, a practical household refrigerator with a hermetically sealed unit was put on the market by General Electric. Today 34 companies are manufacturing household refrigerators with hermetically sealed mechanisms.

* * *

Research and engineering snowplow the way, not only for new public conveniences, but also for new companies, new jobs.

There are 20% more businesses today than there were immediately after the war.

Industry furnishes over 10,000,000 more jobs than ten years ago.

The average family owns more and better products of industry than ten years ago.

Any American company that plows back money into research and engineering development makes new business not only for itself, but for others.

The economy that does most to foster competition is the one that makes easiest the establishment and growth of business.

You can put your confidence in—

GENERAL ELECTRIC